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American Society for Testing Materials

ORGANIZED IN 1898
INCORPORATED IN 1902

PROCEEDINGS, PART I

The Society is not responsible, as a body, for the statements and opinions advanced in this publication.

The following Summary records the action taken by the Society at the Annual Meeting on the Recommendations Affecting Standards and Tentative Standards appearing in the Annual Reports of the Standing Committees. In the individual committee reports attention is called through an editorial footnote to any modifications of the recommendations or where the recommendations of the committee were not approved. In all other instances it is to be understood that the recommendations were approved as submitted by the committee.

SUMMARY OF THE PROCEEDINGS OF THE THIRTY-NINTH ANNUAL MEETING

Atlantic City, N. J., June 29–July 3, 1936

The Thirty-ninth Annual Meeting of the American Society for Testing Materials, was held at Chalfonte-Haddon Hall, Atlantic City, N. J., June 29–July 3, 1936. The following is an analysis of the registered attendance at the meeting: Members in attendance or represented, 757; committee members, 143; guests, 231; total, 1131; ladies, 256. The corresponding statistics for the Thirty-eighth Annual Meeting are as follows: Members in attendance or represented, 766; guests, 246; total, 1012; ladies, 124.

First Session—Tuesday, June 30, 10.30 a. m.

Opening Session

President H. S. Vassar in the chair.

President Vassar in opening the Thirty-ninth Annual Meeting extended a very cordial welcome to all members and guests of the Society in attendance. He expressed a belief that from attendance records and other indications, this meeting promised to be one of the most successful in the history of the Society. President Vassar referred briefly to the complete program for the meeting which included some eighteen technical sessions at which the annual reports of 51 committees and 62 technical papers would be presented. He also stated that the scheduled meetings of standing committees and their subcommittees totaling 180, gave promise of further valuable contributions to the Society in the future.

The President then introduced Cloyd M. Chapman, chairman of Committee E-10 on Standards who presented from manuscript the report of the committee.

President Vassar then presented P. H. Bates, chairman of Committee E-9 on Research, who presented from manuscript the report of the committee.

President Vassar then introduced the Secretary-Treasurer, C. L. Warwick, who presented the report of the Executive Committee. This report on general Society activities covered membership, committee activities, changes in regulations governing standing committees, district committees, meetings, and local activities, publications, finances, inter-society and other cooperative relations. The report announced a decision to discontinue Committee A-4 on Heat Treatment of Iron and Steel. In view of this the Standard Recommended Practices for Annealing of Miscellaneous Rolled and Forged Carbon-Steel Objects (A 35 – 24), for Heat Treatment of Carbon-Steel Castings (A 36 – 24), and for Carburizing and Heat Treatment of Carburized Objects (A 37 – 27) are being withdrawn; and the Standard Definitions of Terms Relating to Heat Treatment Operations (Especially as Related to Ferrous Alloys) (A 119 – 33) placed under the jurisdiction of Committee E-8 on Nomenclature and Definitions.

President Vassar then presented H. C. Parmelee, Editor, ***Engineering and Mining Journal***, McGraw-Hill Publishing Co., who spoke on "Relationship of A.S.T.M. to Modern Developments in Chemical Engineering." Mr. Parmelee presented a very interesting paper[1] in which he described a number of synthetic products and other materials of construction possessing new properties and characteristics which have been developed recently through chemical research and which are finding increasing use in engineering applications. He discussed at some length the synthetic organic chemical compounds or "plastics" including the cellulose derivatives, synthetic resins and rubber derivatives and rubber-like compounds; and also referred briefly to recent applications of carbon, not previously considered as a construction material, to newly developed metals and alloys for severe industrial service and the use of soaps and other detergents as engineering materials.

Past-President Cloyd M. Chapman then assumed the chair.

The chairman presented the President, Hervey S. Vassar, who delivered the annual Presidential Address[2] on "The Testing of Non-Materials," in which he presented for consideration the present-day approach to the numerous problems which have to do with satisfactory living and which so vitally concern every individual. He summarized a few of the attributes which characterize the A.S.T.M., such as, its definite objectives, representative committees, progressiveness, stability, responsibility and high ideals of service to industry, and which assure the continued success of the work of the Society in the field of the physical sciences. In discussing the prevailing popular attitudes toward such subjects as unemployment, labor, social security, he referred to the innumerable influences which are continually at work on each individual in shaping his attitudes toward these social questions. He suggested that a "scientific approach" or perhaps "common-sense approach" to such problems, based on honest, intelligent and unselfish thinking would go far toward a proper solution. President Vassar expressed a belief that "there is within the organized workers in the field of physical science, a potential force fully capable of being the leaven in the meal of society, which can aid mightily in the development of a more rational approach to the problems of today."

The chairman then recognized F. R. Baxter, chairman of the Committee of Tellers, who reported the results of the letter ballot on election of officers. Of the 1124 ballots cast, the results were as follows:

For President, to serve for one year: A. C. Fieldner, 1124 votes.

For Vice-President, to serve for two years: T. G. Delbridge, 1124 votes.

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[1] Published in A.S.T.M. BULLETIN, July, 1936.

[2] See p. 37.

For Members of Executive Committee, to serve for two years:

O. U. Cook, 1103 votes.
H. F. Gonnerman, 1110 votes.
C. S. Reeve, 1103 votes.
F. E. Richart, 1102 votes.
F. M. Waring, 1100 votes.

In accordance with the ballot the chair declared the officers listed above elected.

At the request of the chairman, Past-Presidents Hermann von Schrenk and T. R. Lawson escorted to the chair the President-Elect, A. C. Fieldner. In expressing his sincere appreciation of the honor of his election to the Presidency, Mr. Fieldner made the following remarks:

"It is needless to say that I am happy indeed to receive this honor. It is the greatest honor which any member of our Society can hope to receive, and I thank you for it. I look upon this as a just recognition of the importance of fuels as an engineering material, and especially of coal and its products. I also like to look upon it as a recognition of the work of my numerous associates in the Bureau of Mines who followed the example set by our first director, Dr. Joseph Austin Holmes, who was a member of this Society and the first chairman of the Committee on Sampling of Coal. He set a good precedent and all of us have been very happy to serve the Society whenever we could. My associates in coal and gas divisions, the men in the petroleum division and those in the divisions on metals and other mineral products, have all been happy to serve the Society and hope to continue to do so in the future.

"We have many increased responsibilities; new material from the research laboratories is coming into use. I am appalled at the task ahead of us and ahead of the chairman of this Executive Committee, if it were not for the fact that we have three past-presidents under whose guidance we really cannot fail. I thank you."

The chairman then requested Past-Presidents K. G. Mackenzie and F. O. Clements to escort the Vice-President-Elect, T. G. Delbridge, to the chair, who responded by saying that he realized that the acceptance of that office carries with it certain responsibilities which he was ready to accept and that he would endeavor to perform such duties in the best interests of the Society.

The chairman then presented the newly elected members of the Executive Committee.

The chairman announced that the Third World Power Conference and the Second Congress on Large Dams would be held in Washington, D. C., September 7 to 12, and that President-Elect A. C. Fieldner and Prof. A. E. White had been designated to represent the Society at the conference. The chairman then called upon President-Elect Fieldner who presented a brief description of the purposes and activities of the conference. He stated that the first two conferences, which were devoted to the technical side of power development, were held at London, England, in 1924 and at Berlin, Germany in 1930, respectively. The third conference will be devoted largely to national power economy, considered in its broadest sense of energy sources, development and utilization. Of special interest to the Society are the papers on significant trends in the development and utilization of power resources and their economic relationship; the conservation of coal, oil and natural gas, the utilization and regulation of water resources and national power and resources policy. Engineers from abroad who wish to learn of the latest engineering practices in this country will be accommodated by eight study tours accompanied by technical round-table discussions.

The Congress on Large Dams will also be of particular interest. Papers will be given on special cements, the design and waterproofing of shrinkage, contraction and expansion joints; the facing of masonry and concrete dams; foundation materials and stability of earth dams; and use of precast concrete blocks. Definite acceptances have been received from 29 nations, including all the great industrial powers. Seven hundred foreign delegates are expected, and a total attendance of 3000 is anticipated.

The meeting then adjourned till 2 p. m.

SECOND SESSION—TUESDAY, JUNE 20, 2 P. M.

Fuels, Petroleum Products, Electrical Insulating Materials

(Held Simultaneously with Third Session)

President H. S. Vassar in the chair.

The report of Committee D-9 on Electrical Insulating Materials was presented by the chairman, T. Smith Taylor. The Tentative Method of Test for Saponification Number of Electrical Insulating Oils was accepted for publication as tentative. The proposed revision of the Standard Methods of Testing Molded Materials Used for Electrical Insulation (D 48 – 33) was accepted for publication as tentative.

The proposed revisions of the Tentative Methods of Testing Electrical Insulating Material for Power Factor and Dielectric Constant (D 150 – 35 T), Test for Determining the Electrical Insulating Qualities of Slate (D 273 – 27 T), Testing Varnishes Used for Electrical Insulation (D 115 – 35 T), Testing Solid Filling and Treating Compounds Used for Electrical Insulation (D 176 – 35 T), Testing Untreated Paper Used in Electrical Insulation (D 202 – 34 T), Testing Sheet and Plate Materials Used in Electrical Insulation (D 229 – 35 T), Testing Varnished Cloths and Varnished Cloth Tapes Used in Electrical Insulation (D 295 – 34 T), Test for Grading Natural Mica (D 351 – 35 T), Test for Thickness of Solid Electrical Insulation (D 374 – 34 T), and Specifications for Black Bias-cut Varnished Cloth Tape Used for Electrical Insulation (D 373 – 34 T) were accepted, the methods and specifications as revised being continued as tentative.

The Tentative Methods of Testing Pasted Mica Used in Electrical Insulation (D 352 – 32 T) were approved for reference to letter ballot of the Society for adoption as standard. The tentative revision of the Standard Methods of Testing Electrical Insulating Oils (D 117 – 33) was approved for reference to letter ballot of the Society for adoption as standard.

A paper entitled "Edge Correction in the Determination of Dielectric Constant," by Harvey L. Curtis and Arnold H. Scott, was presented by Mr. Curtis and discussed.

A paper entitled "Significance of Material Tests and of Design Tests upon Electrical Insulating Materials," by L. E. Barringer, was presented by the author and discussed.

A paper entitled "Conditioning of Insulating Materials for Test," by Robert Burns was presented from manuscript by the author and discussed.

Mr. J. B. Rather then assumed the chair.

A paper entitled "Testing for Sludge Formation in Mineral Transformer Oil," by F. M. Clark and E. A. Snyder, was presented by Mr. Clark.

The report of Committee D-2 on Petroleum Products and Lubricants was presented by the chairman, T. A. Boyd. The revisions proposed for immediate adoption in the Standard Methods of Test for Carbon Residue of Petroleum Products (D 189 - 30), for Steam Emulsion of Lubricating Oils (D 157 - 28) and the Abridged Volume Correction Table for Petroleum Oils (D 206 - 34) were unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote.

The revisions proposed for immediate adoption in the Standard Method of Test for Burning Quality of Kerosine Oils (D 187 - 30) were unanimously approved for reference to letter ballot of the Society for adoption as standard, with the following additional changes, presented on the floor at the annual meeting, subject to favorable letter ballot of Committee D-2:[1]

Section 3.—Change the dimension from top of wick holder to base of flame-spreader slot to read as follows by the addition of the italicized figures and the omission of those in brackets:

	INCHES	CENTIMETERS	TOLERANCES, CM.
Top of wick holder to base of flame-spreader slot	[0.03] *0.10*	[0.08] *0.25*	±[0.06] *0.10*

The following revisions presented for immediate adoption on the floor at the annual meeting in the Standard Method of Test for Burning Quality of Long-Time Burning Oil for Railway Use (D 219 - 30) were unanimously approved for reference to letter ballot of the Society, subject to favorable letter ballot of Committee D 2:[2]

Section 4.—Change the following dimensions of the burner to read as follows by the addition of the italicized figures and the omission of those in brackets:

	INCHES	CENTIMETERS	TOLERANCES, CM.
Width of top of V-shaped slots in flame spreader	[0.31] *0.27*	[0.79] *0.69*	±0.08
Rectangular Openings, four in number:			
(1) Height..............................	[0.44] *0.40*	[1.11] *1.02*	±0.08
(2) Width..............................	[0.56] *0.53*	[1.43] *1.35*	±0.08

The proposed revision of the Tentative Method of Test for Knock Characteristics of Motor Fuels (D 357 - 34 T) was accepted, the method as revised being continued as tentative. The tentative revisions of the Standard Methods of Test for Distillation of Crude Petroleum (D 285 - 33), for Flash Point by Means of Pensky-Martens Closed Tester (D 93 - 22), for Saponification Number (D 94 - 28), for Viscosity of Petroleum Products and Lubricants (D 88 - 33), for Flash Point of Volatile Flammable Liquids (D 56 - 21). revisions in the latter two in the form of completely revised methods, and for Gravity of Petroleum and Petroleum Products by Means of the Hydrometer (D 287 - 33), as revised, were approved for reference to letter ballot of the Society for adoption as standard. The Tentative Method of Test for Gum Content of Gasoline (D 381 - 34 T), as revised, was approved for reference to letter ballot of the Society for adoption as standard. The withdrawal of the Standard Methods of Test for Flash Point of Volatile Flammable Liquids (D 56 - 21) and for Viscosity of Petroleum Products and Lubricants (D 88 - 33) was approved.

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[1] This recommendation was submitted to letter ballot of Committee D-2 which consists of 87 members; 62 members returned their ballots, of whom 52 have voted affirmatively and none negatively.

[2] This recommendation was submitted to letter ballot of Committee D-2 which consists of 87 members; 62 members returned their ballots, of whom 52 have voted affirmatively and none negatively.

The Proposed Method of Test for Kinematic Viscosity by Means of the Suspended Level Viscosimeter, which did not appear in the report as preprinted, was accepted for publication in the report as information, subject to favorable letter ballot of Committee D-2.[1]

The Proposed Method of Test for Kinematic Viscosity by Means of the Modified Ostwald Viscosimeter, which appeared in Appendix II of the report as preprinted, was accepted for publication in the report as information with the following changes, presented on the floor at the annual meeting, subject to favorable letter ballot of Committee D-2:[2]

Table I.—Change the distance from center of bulb *B* to center of bulb *C* from "85 to 90 mm." to read "85 to 95 mm."

Fig. 1.—Redraw to scale the illustration of the modified Ostwald viscosimeter.

Section 3 (*f*).—Change to read as follows by the addition of the italicized word:

> (*f*) The viscosimeter shall remain in the constant-temperature bath long enough to reach the bath temperature. The *minimum* time required is 5 min. for the 100 F. (38 C.) bath, and 10 min. for the 210 F. (99 C.) bath.

Section 3 (*g*).—Change the last sentence from its present form: namely,

> When the oil level is brought to the etched line between the bulb this air shall be removed. It shall be absent so that there is an unbroken column of oil extending from the lower reservoir through the capillary during the test.

to read as follows:

> When the oil level is brought to the etched line between the bulbs this air shall be removed, so that there will be an unbroken column of oil extending from the lower reservoir through the capillary during the test.

The Proposed Method for Converting Kinematic Viscosity to Saybolt Seconds, presented on the floor at the annual meeting, was accepted for publication in the report as information, subject to favorable letter ballot of Committee D-2.[3]

The report on Suggested Uniform Automotive Engine Lubrication Recommendations, prepared as a guide to automobile owners in the changing of crankcase oils, which was presented on the floor at the annual meeting, was accepted for publication in the report as information, subject to favorable letter ballot of Committee D-2.[4]

The Diesel-Fuel-Oil Classification with the following revisions, presented on the floor at the annual meeting, was accepted for publication in the report as information, subject to favorable letter ballot of Committee D-2:[5]

Table I.—In this table, change the viscosity values for oils Nos. 1-D and 3-D to read as follows by the addition of the italicized figures and the omission of those in brackets:

GRADE OF DIESEL FUEL	VISCOSITY, SAYBOLT UNIVERSAL (AT 100 F.), SEC. MIN.	MAX.
No. 1-D	[32] *35*	50
No. 3-D	[32] *35*	70

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[1] This recommendation was submitted to letter ballot of Committee D-2 which consists of 87 members; 62 members returned their ballots, of whom 55 have voted affirmatively and 1 negatively.

[2] This recommendation was submitted to letter ballot of Committee D-2 which consists of 87 members; 62 members returned their ballots, of whom 50 have voted affirmatively and 1 negatively.

[3] This recommendation was submitted to letter ballot of Committee D-2 which consists of 87 members; 62 members returned their ballots, of whom 57 have voted affirmatively and none negatively.

[4] This recommendation was submitted to letter ballot of Committee D-2 which consists of 87 members; 62 members returned their ballots, of whom 53 have voted affirmatively and 1 negatively.

[5] This recommendation was submitted to letter ballot of Committee D-2 which consists of 87 members; 62 members returned their ballots, of whom 49 have voted affirmatively and 1 negatively.

Change footnote "c" of Table I to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

> Lower pour points may be specified whenever required by local temperature conditions to facilitate storage and use, although *the minimum viscosity specified for Oils Nos. 1-D and 3-D must be waived whenever* it [should not be] *is* necessary to [specify] *require* a pour point of less than [0 F.] *10 F.*

Table II.—In this table, change the cetane number values to read as follows by the addition of the italicized words and figures and the omission of the figures in brackets:

	OIL GRADES		
	No. 1-D	No. 3-D	No. 4-D
Cetane number *by the delay method*, min.............	[50] *45*	[40] *35*	30

The Proposed Potentiometric Method for Neutralization Number of Petroleum Products and Lubricants, prepared under the joint cooperation of Committee D-2 and Committee D-9 on Electrical Insulating Materials, presented on the floor at the annual meeting, was accepted for publication in the report as information, subject to favorable letter ballot of Committee D-2.[1]

It was announced that the committee had prepared revisions of the terms petroleum grease, tar and pitch in the Tentative Definitions of Terms Relating to Petroleum (D 288 – 35 T) which would be submitted to the Society through Committee E-10 on Standards subsequent to the annual meeting. It was also announced that the committee contemplates the submission to Committee E-10 of revisions of the Tentative Specifications for Fuel Oils (D 396 – 34 T) after favorable letter ballot of Technical Committee C and Committee D-2.

The report of Committee D-3 on Gaseous Fuels was presented by the chairman, A. C. Fieldner.

The report of the Sectional Committee on Classification of Coals was presented by the chairman, A. C. Fieldner. The proposed Tentative Method for Designating the Size of Coal from Its Screen Analysis was accepted for publication as tentative. The proposed revisions of the Tentative Specifications for Classification of Coals by Rank (D 388 – 35 T) were accepted, the specifications as revised being continued as tentative.

The report of Committee D-5 on Coal and Coke was presented by the chairman, A. C. Fieldner. The proposed revision of the Standard Methods of Laboratory Sampling and Analysis of Coal and Coke (D 271 – 33) was accepted for publication as tentative.

The meeting then adjourned till 8 p. m.

THIRD AND FOURTH SESSIONS—TUESDAY, JUNE 30, 2 P. M., AND 8 P. M.

Symposium on Radiography and X-ray Diffraction Methods

(Held Simultaneously with Second and Fifth Sessions, Respectively)

Radiography

Mr. H. H. Lester in the chair.

Messrs. R. H. Aborn, W. C. Hamilton and C. A. Adams, co-chairmen.

Mr. Lester in opening the Symposium on Radiography and X-ray Diffraction

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[1] This recommendation was submitted to letter ballot of Committee D-2 which consists of 87 members; 62 members returned their ballots, of whom 53 have voted affirmatively and 1 negatively.

Methods, called attention to the fact that the 12 papers comprising the symposium would be presented in two groups of six papers each, on Radiography and Diffraction, respectively. He stated that the symposium had been arranged under the auspices of Committee E-4 on Metallography, through its Subcommittee VI on X-ray Methods under the chairmanship of R. F. Mehl.

Mr. Lester then introduced the Secretary-Treasurer, C. L. Warwick, who, on behalf of Doctor Mehl who was unable to attend the symposium, presented a brief introduction to the symposium submitted in writing by Doctor Mehl. The statement from Doctor Mehl briefly summarized the considerations of the committee in arranging for the symposium. He stated that in developing its program of work the committee recognized that the use of X-ray methods in the testing of materials had developed rapidly in the past 15 years and had reached a position of considerable industrial importance in the testing field. It was appreciated that the present state of the art was such as to warrant close observation by those seriously interested in studying the behavior of materials. It was evident from the informal symposium held at the 1935 annual meeting that a formal exposition on the subject would be an excellent contribution in eliciting further developments in this important branch of the testing of materials. This symposium was accordingly arranged to bring to the testing public a critical account of the methods available, a discussion of the present status of the various testing methods with a critical comparison with other methods, and a suggestion of what may well lie in the future in this field with the further development of the art.

The co-chairmen, R. H. Aborn, W. C. Hamilton and C. A. Adams, presided in turn during the presentation of the following three papers on Radiography, comprising the Third Session:

"The Principles of the Radiographic Process," by John T. Norton, presented from manuscript by the author and discussed.

"Foundry Applications of Radiography," by Earnshaw Cook, presented from manuscript by the author and discussed.

"Radiography in the Welding Shop," by J. C. Hodge, presented from manuscript by the author and discussed.

Messrs. J. T. Norton, C. W. Briggs and R. A. Bull, co-chairmen.

The second group of three papers on Radiography, comprising the Fourth Session, were introduced, respectively, by the co-chairmen, as follows:

"Miscellaneous Applications of Radiography and Fluoroscopy," by Herman E. Seemann, presented from manuscript by the author and discussed.

"Gamma-ray Radiography and Its Relation to X-ray Radiography," by Norman L. Mochel, presented from manuscript by the author and discussed.

"Problems of Radiographic Specifications," by H. H. Lester, presented from manuscript by the author and discussed.

The meeting then adjourned till the following morning, the symposium being continued in the Seventh and Eighth Sessions.

FIFTH SESSION—TUESDAY, JUNE 30, 8 P. M.

Water

(Held Simultaneously with Fourth Session)

Past-President Hermann von Schrenk in the chair.

Messrs. C. H. Fellows and Max Hecht, co-chairmen.

Mr. von Schrenk in opening the session stated that the program had been arranged under the joint auspices of Committee D-19 on Water for Industrial Uses and the

Joint Research Committee on Boiler Feedwater Studies. He extended a cordial welcome to the attending members of these committees and the representatives of the national associations, guests and members of the Society interested in the subject of water for industrial uses.

Mr. von Schrenk then introduced the co-chairmen, C. H. Fellows and Max Hecht.

The report of Committee D-19 on Water for Industrial Uses was presented by the chairman, Max Hecht. In presenting the report Mr. Hecht called upon T. H. Dougherty to describe the activities of Subcommittee III on Methods of Sampling and on J. R. McDermet to present the report of Subcommittee IV on Methods of Analysis.

The report of the Joint Research Committee on Boiler Feedwater Studies was presented from manuscript by the chairman, C. H. Fellows.

A paper entitled "The Use of Solubility Data to Control the Deposition of Sodium Sulfate or Its Complex Salts in Boiler Waters," by W. C. Schroeder, A. A. Berk and Everett P. Partridge, was presented by Mr. Berk and discussed.

A paper entitled "Effect of Solution Composition on the Failure of Boiler Steel Under Static Stress at 250 C.," by W. C. Schroeder, A. A. Berk and Everett P. Partridge, was presented by Mr. Schroeder and discussed.

A paper entitled "Determination of Dissolved Oxygen in Boiler Feed Water," by Alfred H. White, Claude H. Leland and Dale W. Button, was presented by Mr. White and discussed.

A paper entitled "The Rate of Reaction of Sodium Sulfite with Oxygen Dissolved in Water," by R. M. Hitchens and R. W. Towne, was presented by Mr. Hitchens and discussed.

The meeting then adjourned till the following morning.

SIXTH SESSION—WEDNESDAY, JULY 1, 9.30 A. M.

Corrosion, Effect of Temperature, Creep

(Held Simultaneously with Seventh Session)

Vice-President A. E. White in the chair.

The report of Committee A-5 on Corrosion of Iron and Steel was presented by the chairman, F. F. Farnsworth. The Tentative Method of Test for Uniformity of Coating by the Preece Test (Copper Sulfate Dip) on Zinc-Coated (Galvanized) Iron or Steel Wire was accepted for publication as tentative. In presenting the report Mr. Farnsworth called upon R. F. Passano to present the report of Subcommittee VIII on Field Tests of Metallic Coatings which had been accepted by the committee for inclusion in its annual report but had not been preprinted.

A verbal progress report of Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys was presented by the chairman, T. S. Fuller.

The report of the Joint Committee on Exposure Tests of Plating on the Non-Ferrous Metals was presented by the chair.

The report of Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys was presented by the chair.

Mr. N. L. Mochel then assumed the chair.

The report of the Joint Research Committee on Effect of Temperature on the Properties of Metals was presented by the chairman, H. J. French. In presenting the report Mr. French called upon Mr. Sergeson to present the "General Summary and Comparison of Procedure and Results Obtained on Cooperative Study of Low-Temperature Impact Testing of 0.35 per cent Carbon Steel (K20)," prepared for Subcommittee P from the reports of 11 laboratories by R. Sergeson and S. W. Poole. Mr. French also called upon Mr. Cross to present the "Report on Long-Time Creep Tests of 18 per cent Chromium, 8 per cent Nickel Steel, and 0.35 per cent Carbon Steel," prepared by H. C. Cross and F. B. Dahle as a report to the Joint Committee covering a sponsored research project carried out at Battelle Memorial Institute.

A paper entitled "Slow-Bend and Impact Tests of Notched Bars at Low Temperatures," by H. F. Moore, H. B. Wishart and S. W. Lyon, was presented by Mr. Moore and discussed.

A paper entitled "A Direct Load Creep Test Machine," by J. J. Curran and F. H. Morehead, was presented from manuscript by Mr. Curran and discussed.

A paper entitled "Some Creep Tests on Lead and Lead Alloys," by Albert J. Phillips, was presented by the author and discussed.

A paper entitled "Influence of Time at 1000 F. on the Characteristics of Carbon Steel," by A. E. White, C. L. Clark and R. L. Wilson, was presented by Mr. Wilson and discussed.

The meeting then adjourned till 2 p. m.

SEVENTH AND EIGHTH SESSIONS—WEDNESDAY, JULY 1, 9.30 A. M., AND 2 P. M.

Symposium on Radiography and X-ray Diffraction Methods

(Continued from Fourth Session; Held Simultaneously with Sixth Session)

Diffraction

Messrs. Eric R. Jette and William L. Fink, co-chairmen.

Mr. Jette in opening the second section of the symposium, devoted to Diffraction methods, explained briefly the distinction between diffraction phenomena and radiographic technique.

The first group of three papers on Diffraction, comprising the Seventh Session, was then introduced by the co-chairmen, as follows:

"Equipment and Methods," by Charles S. Barrett, presented from manuscript by the author and discussed.

"Constitution of Alloys," by Kent R. Van Horn, presented from manuscript by the author.

"Chemical Analysis by X-ray Diffraction Methods," by Wheeler P. Davey, presented from manuscript by the author and discussed.

Messrs. J. D. Hanawalt and R. M. Bozorth, co-chairmen.

The second group of three papers on Diffraction, comprising the Eighth Session, was introduced by the co-chairmen, as follows:

"Applications of X-ray Methods to Problems of Cold Work, Preferred Orientations, and Recrystallization," by John T. Norton, presented from manuscript by the author.

"The X-ray Determination of Particle Size," by G. Harvey Cameron and A. L. Patterson, presented from manuscript by Mr. Cameron.

"The Applications of the X-ray Diffraction Method to Non-Metallic Materials," by George L. Clark, presented from manuscript by the author.

The meeting then adjourned till 4 p. m.

NINTH SESSION—WEDNESDAY, JULY 1, 4 P. M.

Edgar Marburg Lecture

President H. S. Vassar in the chair.

President Vassar in opening the session devoted to the Edgar Marburg Lecture referred briefly to the purpose and significance of this lecture which was instituted in 1926 for the purpose of commemorating annually the name of the first Secretary-Treasurer of the Society, Dr. Edgar Marburg—one who placed the work of the Society on a firm foundation and through whose supervision and foresight, through the developments of research activities and technical programs, brought wide recognition to the Society as a forum for the discussion of properties and tests of engineering materials; and also to bring to the Society men of especial distinction in various branches of the engineering profession to the end that the members might receive inspiration through the lecture and learn of the latest developments in the sciences of engineering materials in which the Society is interested.

The President then introduced the eleventh Edgar Marburg Lecturer, Dr. Arthur L. Day, Director of the Geophysical Laboratory of the Carnegie Institution of Washington, who chose as the subject of the lecture "Developing American Glass." Doctor Day in outlining the early history of glass development stressed particularly the many important contributions of American industry through glass research in perfecting the material and the various melting and forming processes. He emphasized the fact that the composition of practically all common glass from the earliest samples that are available to that of today is substantially the same, the differences being really insignificant from a chemical standpoint. He discussed in detail the silica type glasses made from silica with lime and soda as the fluxing agents, the simplest glass both chemically and physically, and the borosilicate glasses, which use borax and boric acid as the fluxing agents, which had their beginning in Faraday's laboratory and which have greater stability both chemically and physically than the silica glasses. He stated that the most distinguished application of the borosilicate-type glass was in the recently successful pouring of the 200-in. diameter telescope lens for the Mount Wilson Observatory in California, which was made of a glass with an expansion coefficient of one-third that of ordinary window glass, and required a temperature of 1550 C. in its manufacture, which is twice that used for window glass. Doctor Day stated that if high temperatures could be handled more economically, fireproof glass would be practicable. In his talk he referred to recent developments in the making of stronger glass by oil quenching, which requires extreme care in manufacture in order to guard against overquenching, as this sets up internal stresses that may cause the glass to explode. The lecture was illustrated with slides and motion pictures which assisted in conveying an excellent conception of the various processes and developments covered by Doctor Day in his lecture.

President Vassar in expressing appreciation to Doctor Day for his fine, interesting and instructive lecture on a subject of direct interest to the Society, presented to him, on behalf of the Society, the Edgar Marburg Lecture Certificate.

President Vassar then recognized N. L. Mochel, chairman of the Committee on Award of the Charles B. Dudley Medal. Mr. Mochel presented Mr. H. C. Mann as the recipient of the 1936 Award of the Dudley Medal for his paper on "The Relation Between the Tension Static and Dynamic Tests," delivered before the 1935 annual meeting of the Society and considered by the committee as a paper of outstanding merit constituting an original contribution on research in materials.

On behalf of and as the representative of the Society, President Vassar then made the award of the Charles B. Dudley Medal to Mr. Mann.

In accepting the medal, Mr. Mann expressed his appreciation of the award as follows:

> "Mr. President, members of the A.S.T.M.: I can assure you that the honor which the award of this medal conveys is sincerely appreciated. As you know, we have been interested in impact testing for many years, and to have our contribution receive this recognition is most gratifying. I wish to add that much of the credit for the success of this work has been due in part to the progressive aid of the Ordnance Department towards fundamental research, and in part to the keen interest and active aid and encouragement of Col. G. F. Jenks, Commanding Officer of the Arsenal, and the director of laboratories at the Arsenal. I thank you."

The meeting then adjourned till 8 p. m.

TENTH SESSION—WEDNESDAY, JULY 1, 8 P. M.

Testing, Fatigue of Metals, Spectrographic Analysis

Past-President T. R. Lawson in the chair.

The report of Committee E-3 on Chemical Analysis of Metals was presented by the chairman, G. E. F. Lundell. It was announced that the committee had completed the preparation of completely revised and improved Methods of Chemical Analysis of Steel, Wrought Iron, Open-Hearth Iron and Cast Iron which will be presented to the Society for publication as tentative through Committee E-10 on Standards subsequent to the annual meeting to replace the existing Standard Methods of Chemical Analysis of Plain Carbon Steel (A 33 - 24), of Alloy Steels (A 55 - 24), of Sampling Rolled and Forged Steel Products for Check Analysis (A 130 - 30) and of Sampling and Chemical Analysis of Pig and Cast Iron (A 64 - 27), the withdrawal of which standards would also be recommended. It was also announced that the committee contemplated recommending to Committee E-10 that the existing standard methods under its jurisdiction covering sampling and chemical analysis of ferroalloys and the non-ferrous metals be reverted to the status of tentative methods since the committee is planning to improve and develop procedures on these subjects and to consolidate certain of the present analytical methods.

The report of Committee E-2 on Spectrographic Analysis was presented by the chairman, H. V. Churchill. It was announced that the committee had completed the preparation of a bibliography on spectrographic analysis which the committee wished to have published subject to the approval of Committee E-6 on Papers and Publications.

A paper entitled "The Spectrographic Determination of Magnesium in Aluminum Alloys," by W. R. Koch, was presented from manuscript by the author and discussed.

A paper entitled "Developments in the Quantitative Analysis of Solutions by Spectroscopic Means," by O. S. Duffendack and K. B. Thomson, was presented by Mr. Duffendack and discussed.

A verbal progress report of Committee D-15 on Thermometers and Laboratory Glassware was presented by the chairman, W. H. Fulweiler.

The report of Committee E-1 on Methods of Testing was presented by the chairman, W. H. Fulweiler. The revisions proposed for immediate adoption in Sections 25 and 26 of the Standard Methods of Tension Testing of Metallic Materials (E 8 - 33) were unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote. It was announced that the committee had decided to withdraw the recommendation which appeared in the report as preprinted respecting the omission of Section 5 from the Standard Methods E 8 – 33.

The Tentative Methods of Rockwell Hardness Testing of Metallic Materials (E 18 – 33 T), as revised, Definitions of Terms Relating to Methods of Testing (E 6 – 35 T), as revised, and Specifications for Round-Hole Screens for Testing Purposes (E 17 – 35 T), the latter to replace the existing standard, were approved for reference to letter ballot of the Society for adoption as standard.

The recommendation that the Tentative Methods of Verification of Testing Machines (E 4 – 35 T), with revisions in Sections 19 and 29, be approved for reference to letter ballot of the Society for adoption as standard, was discussed. It was pointed out in the discussion that the provision proposed for inclusion in the second sentence of Section 29, requiring that testing machines shall be verified "after the testing machine has been moved" would not be applicable in the case of portable machines. It was stated that this was an oversight on the part of the committee in preparing this revision and on motion the recommended revision in the second sentence of Section 29 was amended by the addition of the words: "this does not apply to portable testing machines." The recommendation, as amended, was approved.

With this change the second sentence of Section 29 will then read as follows:

> Testing machines shall, however, be verified immediately after making repairs or adjustments of the weighing mechanism, *after the testing machine has been moved* (*this does not apply to portable testing machines*), and whenever there is reason to doubt the accuracy of the results, without regard to the time interval since the last verification.

In presenting the report Mr. Fulweiler called upon H. F. Moore to describe the activities of Technical Committee I on Mechanical Testing, on D. L. Gamble to discuss the work of Technical Committee III on Particle Size and Shape, on H. F. Dodge to describe the activities of Technical Committee IX on Interpretation and Presentation of Data, and on J. A. Gann to report on the work of Technical Committee XI on Designation and Interpretation of Numerical Requirements. It was announced by Mr. Gann that Technical Committee XI had completed a Proposed Recommended Practice for the Designation of Numerical Requirements in Standards for publication as information in an appendix to the report.

A verbal progress report of the Sectional Committee on Specifications for Sieves for Testing Purposes was presented by the secretary, L. V. Judson.

A paper entitled "Applications of the Wedge Extensometer," by Wilbur M. Wilson, was presented by F. E. Richart and discussed.

A paper entitled "High-Velocity Tension-Impact Tests," by H. C. Mann, was presented by the author and discussed.

The report of the Research Committee on Fatigue of Metals was presented by the chairman, H. F. Moore. Attention was called to an appendix describing an investigative study on "X-ray Diffraction as a Means of Detecting Impending Fatigue Failure," carried on in cooperation with Committee E-4 on Metallography.

A paper entitled "Damage and Overstress in the Fatigue of Ferrous Materials," by H. W. Russell and W. A. Welcker, Jr., was presented by Mr. Russell and discussed.

The meeting then adjourned till the following morning.

ELEVENTH SESSION—THURSDAY, JULY 2, 9.30 A. M.

Iron and Steel

(Held Simultaneously with Twelfth Session)

Mr. L. S. Marsh in the chair.

The report of Committee A-3 on Cast Iron was presented by the chairman, Hyman Bornstein. The Tentative Specifications for Lightweight Thin-Sectioned Gray-Iron Castings were accepted for publication as tentative. The Tentative Specifications for Gray-Iron Castings (A 48 – 35 T), with editorial changes, were approved for reference to letter ballot of the Society for adoption as standard. The withdrawal of the Standard Specifications for Chilled Cast-Iron Wheels (A 46 – 24) was approved.

It was announced that the committee had completed the preparation of definitions of terms relating to cast iron which would be submitted to the Society through Committee E-10 on Standards subsequent to the annual meeting. These definitions which also included certain terms relating to malleable iron would be subject to review by Committee E-8 on Nomenclature and Definitions.

A verbal progress report of Committee A-7 on Malleable Iron Castings was presented by H. A. Schwartz. It was announced that the committee had completed the preparation of specifications for cupola malleable iron which would be submitted to the Society for publication as tentative through Committee E-10 on Standards, subsequent to the annual meeting.

The report of Committee A-2 on Wrought Iron was presented by the vice-chairman, James Aston. The Tentative Specifications for Single and Double Refined Wrought-Iron Bars were accepted for publication as tentative. The proposed revisions of the Tentative Specifications for Wrought-Iron Rivets and Rivet Rounds (A 152 - 35 T) were accepted, the specifications as revised being continued as tentative. The revisions proposed for immediate adoption in the Standard Specifications for Refined Wrought-Iron Bars (A 41 – 30), for Staybolt, Engine-Bolt and Other High-Grade Wrought-Iron Bars (A 84 – 33) in the form of completely revised Standard Specifications for Staybolt Wrought Iron, Solid, and for Hollow Rolled Staybolt Iron (A 86 - 35) were unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote.

The Tentative Specifications for Uncoated Wrought-Iron Sheets (A 162 – 35 T) and for Zinc Coated (Galvanized) Wrought-Iron Sheets (A 163 – 35 T) were approved for reference to letter ballot of the Society for adoption as standard.

The tentative revisions of the Standard Specifications for Wrought-Iron Rolled or Forged Blooms and Forgings for Locomotives and Cars (A 73 – 30), for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 – 34), for Staybolt, Engine-Bolt and Other High-Grade Wrought-Iron Bars (A 84 – 33), for Refined Wrought-Iron Bars (A 41 – 30), for Common Iron Bars (A 85 – 27) and for Hollow Rolled Staybolt Iron (A 86 – 35) were approved for reference to letter ballot of the Society for adoption as standard. Attention was called to the fact that in the case of the adoption of the tentative revisions of Specifications A 41, this had been inadvertently omitted from the report as preprinted.

The recommendation, presented on the floor at the annual meeting, for the withdrawal of the Standard Specifications for Wrought-Iron Plates (A 42 – 30) was approved subject to favorable letter ballot of Committee A-2[1] since these specifications have been superseded by the Tentative Specifications for Wrought-Iron Plates (A 42 – 35 T).

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[1] This recommendation was submitted to letter ballot of Committee A-2 which consists of 54 members; 43 members returned their ballots, of whom 38 have voted affirmatively and none negatively.

It was announced that the committee had completed certain revisions in the Tentative Specifications A 42 – 35 T which, if approved by letter ballot of the committee, would be submitted to the Society for acceptance through Committee E-10 on Standards, subsequent to the annual meeting.

The report of Committee A-6 on Magnetic Properties was presented by the chairman, Thomas Spooner. The Tentative Definitions of Terms, with Units and Symbols, Relating to Magnetic Testing (A 127 – 35 T) were unanimously approved for reference to letter ballot of the Society for adoption as standard, to replace the present Standard Definitions A 127 – 34, with the following changes in the definitions presented on the floor at the annual meeting, subject to favorable letter ballot of Committee **A-6**:[1]

Maxwell.—Change to read as follows by the addition of the italicized words:

> Maxwell.—The flux through a surface of uniform induction when the product *of the normal component* of the induction in gausses and the surface area in square centimeters is unity.

Intrinsic Induction in a Ferromagnetic Material.—Change the equation accompanying this definition from its present form: namely,

$$B_i = B - H$$

to read as follows:

$$B_i = B - \mu_0 H$$

Magnetic Flux.—Change to read as follows by the addition of the italicized words:

> Magnetic Flux (Flux), **Φ**.—The surface integral *of the normal component* of the magnetic induction over a given area.

Magnetic Induction.—Change from its present form: namely,

> *Magnetic Induction* (*Magnetic Flux Density*), *B*.—The vector magnetic quantity accompanying and having the same direction at a point in an isotropic medium as the magnetizing force at the point, but having a magnitude which is dependent upon the properties of the medium.
>
> NOTE.—The magnitude is measured by the electromotive force produced in an electric circuit when the circuit is linked with the induction at a definite time rate. Thus:
>
> $$e = N \frac{dB}{dt}$$
>
> where e is the electromotive force produced in a circuit which is linked N times with the magnetic field of unit cross-sectional area and of uniform induction B.

to read as follows:

> *Magnetic Induction* (*Magnetic Flux Density*), *B*.—The vector magnetic quantity which, at any point in a magnetic field, determines the electromotive force induced in an electric circuit which is linked with the field at a definite time rate. Thus:
>
> $$e = N \frac{dB}{dt}$$
>
> where e is the electromotive force produced in a circuit which is linked N times with a magnetic field of unit cross-sectional area and of uniform induction B.

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[1] This recommendation was submitted to letter ballot of Committee A-6 which consists of 17 members; 13 members returned their ballots all of whom have voted affirmatively.

> NOTE.—In isotropic materials, magnetic induction and magnetizing force have the same (or opposite) direction. In anisotropic materials (such as single crystals and fabricated metals) the direction of the induction is a function of the magnitude of the magnetizing force, the orientation of the crystal axes of the material and its previous condition of magnetization.

Magnetizing Force.—Change the first sentence to read as follows by the addition of the italicized words:

> That vector magnetic quantity arising from electric currents which at a given point ***in a continuous homogeneous medium*** depends only on the position of the point relative to the currents and on their magnitude.

Permeability Space.—After the name of this term, insert the symbol: μ_v.

The revisions proposed for immediate adoption of the Standard Methods of Test for Magnetic Properties of Iron and Steel (A 34 – 33) were unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote, with the additional editorial change, presented on the floor at the annual meeting, comprising the inclusion of the following Note 2 under Section 11 (*c*):

> NOTE 2.—Care should be exercised in the use of rectifier instruments to avoid errors due to variations caused by temperature changes and other variables.

The report of the Sectional Committee on Standardization of Dimensions and Material of Wrought-Iron and Wrought-Steel Pipe and Tubing was presented by the chairman, H. H. Morgan.

The report of Committee A-1 on Steel was presented by the chairman, H. H. Morgan. The Tentative Specifications for High-Carbon-Steel Joint Bars, to replace the present Standard Specifications for High-Carbon-Steel Splice Bars (A 5 – 14); for Quenched Carbon-Steel Joint Bars, to replace the present Standard Specifications for Quenched High-Carbon-Steel Splice Bars (A 49 – 21); for Structural Nickel Steel, to replace the present Standard Specifications for Structural Nickel Steel (A 8 – 29); for Fabricated Bar or Rod Mats for Concrete Reinforcement; for Welded Wire Fabric for Concrete Reinforcement; for One-Wear and Two-Wear Wrought Steel Wheels; for Seamless Alloy-Steel (4 to 6 per cent Chromium) Still Tubes for Refinery Service; and for Seamless Cold-Drawn Alloy-Steel (4 to 6 per cent Chromium) Heat-Exchanger and Condenser Tubes were accepted for publication as tentative.

The revisions proposed for immediate adoption in the Standard Specifications for Wrought Solid Carbon-Steel Wheels for Steam Railway Service (A 57 – 29) in the form of completely revised specifications entitled "Specifications for Multiple Wear Wrought-Steel Wheels," were unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote. The proposed revisions of the Tentative Specifications for Carbon-Steel Castings for Miscellaneous Industrial Uses (A 180 – 35 T) in the form of completely revised tentative specifications designated A 27 – 36 T, to replace the existing Standard Specifications for Carbon-Steel Castings (A 27 – 24), and of the Tentative Specifications for Heat-Treated Carbon-Steel and Alloy-Steel Track Bolts (A 183 – 35 T) were accepted, the specifications as revised being continued as tentative.

The Tentative Specifications for Axle-Steel Concrete Reinforcement Bars (A 160 – 35 T), for Alloy-Steel Castings for Structural Purposes (A 148 – 33 T) as revised, for Carbon-Steel and Alloy-Steel Castings for Railroads (A 87 – 35 T), for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses (A 120 – 34 T), for Electric-Fusion-Welded Steel Pipe (Sizes 30 in.

and Over) (A 134 – 32 T), for Electric-Fusion-Welded Steel Pipe (Sizes 8 in. to but not Including 30 in.) (A 139 – 34 T), for Carbon-Steel Plates for Boilers and Other Pressure Vessels for Stationary Service (A 70 – 35 T), as revised, for High Tensile Strength Carbon-Steel Plates for Pressure Vessels (Plates 2 in. and Under in Thickness) (A 149 – 35 T), as revised, for High Tensile Strength Carbon-Steel Plates for Fusion-Welded Pressure Vessels (Plates over 2 in. up to and Including 4 in. in Thickness) (A 150 – 35 T), as revised, for Lap-Welded and Seamless Steel Pipe for High-Temperature Service (A 106 – 34 T) and for Electric-Fusion-Welded Steel Pipe for High-Temperature and High-Pressure Service (A 155 – 34 T) were approved for reference to letter ballot of the Society for adoption as standard.

The Tentative Specifications for Alloy-Steel Castings for Valves, Flanges and Fittings for Service at Temperatures from 750 to 1100 F. (A 157 – 35 T), for Seamless Alloy-Steel Pipe for Service at Temperatures from 750 to 1100 F. (A 158 – 35 T) and for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for Service at Temperatures from 750 to 1100 F. (A 182 – 35 T) were unanimously approved for reference to letter ballot of the Society for adoption as standard with the changes given below presented on the floor at the annual meeting, subject to favorable letter ballot of Committee A-1.[1] In presenting this recommendation Mr. Morgan called upon A. E. White to read the proposed revisions, which are as follows:

Tentative Specifications for Alloy-Steel Castings for Valves, Flanges and Fittings for Service at Temperatures from 750 to 1100 F. (A 157 – 35 T):

Section 5.—In the table of chemical requirements following this section make the following changes in Grades C6, C9 and C10:

Grade C6.—Change the manganese content from "1.00 max. per cent" to read "0.75 max. per cent."

Grade C9.—Change the nickel content from "8.00 to 10.30 per cent" to read "8.00 min. per cent"; also change the chromium content from "17.5 to 20.0 per cent" to read "18.00 min. per cent."

Add the following as explanatory footnote "a" in connection with Grade C9:

[a] For the more severe general corrosive conditions, and when so specified, the carbon content shall not exceed 0.07 per cent.

The addition of such elements as molybdenum, tungsten, titanium, columbium and vanadium for purposes of stabilization shall be a matter of agreement between the manufacturer and purchaser.

When the purchaser requires free-machining or better non-seizing, non-galling properties, the composition may contain suitable combinations of selenium and phosphorus or molybdenum and sulfur:

Selenium and Phosphorus	Selenium, per cent	0.20 to 0.35
	Phosphorus, max., per cent	0.17
Molybdenum and Sulfur	Molybdenum, per cent	0.40 to 0.80
	Sulfur, per cent	0.20 to 0.40

Grade C10.—Change the chromium content from "7.00 to 9.00 per cent" to read "8.00 to 10.00 per cent."

Section 8.—In the tabulation of tensile properties, change the column heading "yield strength" to read "yield point."

Section 8 (c).—Change to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

(*c*) *The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine, or by the use of dividers, at a crosshead speed not to exceed 1/8 in. per min. Where a definite yield point is not exhibited* the yield strength

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[1] Committee A-1 reported the following results on these recommendations of the letter ballot vote of a total of 144 ballots returned from a committee membership of 206: A 157 – 35 T, affirmative 74, negative 8, and 62 ballots marked "not voting"; A 158 – 35 T, affirmative 66, negative 6, and 72 ballots marked "not voting"; A 182 – 35 T, affirmative 69, negative 5, and 70 ballots marked "not voting."

[shall correspond] ***corresponding*** to a limiting permanent set of 0.2 per cent of the gage length of the specimen ***shall be used instead.*** The "set method" of determining yield strength as described in the Standard Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8) of the American Society for Testing Materials shall be followed. The tensile strength shall be determined at a crosshead speed of not to exceed 1½ in. per min.

Section 9 (*b*).—Change to read as follows by the addition of the italicized words and figures:

(*b*) When a bend test is specified, the test specimens ***for all grades excepting Grade C9, in which case the bending shall be through an angle of 120 deg.,*** shall stand being bent cold through an angle of 90 deg. around a pin 1 in. in diameter, without cracking on the outside of the bent portion.

***Section 10.*—Add the following as a new Paragraph (*c*) to this section:**

(*c*) Bend test specimens, when specified, shall be machined to 1 by ½ in. in section with the long edges rounded to a radius of not over $\frac{1}{16}$ in.

Tentative Specifications for Seamless Alloy-Steel Pipe for Service at Temperatures from 750 to 1100 F. (A 158 - 35 T):

Section 6.—In the tabulation of chemical requirements make the following changes in Grades P1, P2, P3, P11, P12, P6, P8 and P9:

Grades P1 and P2.—Change the sulfur content from "0.045 max. per cent" to read "0.05 max. per cent."

Grade P3.—Change the phosphorus content from "0.03 max. per cent" to read "0.04 max. per cent"; also change the sulfur content from "0.04 max. per cent" to read "0.05 max. per cent."

Grade P11.—Change the phosphorus content from "0.03 max. per cent" to read "0.04 max. per cent"; also change the sulfur content from "0.03 max. per cent" to read "0.05 max. per cent."

Grade P12.—Change the manganese content from "0.30 to 0.60 per cent" to read "0.40 to 0.70 per cent"; also change the sulfur content from "0.045 max. per cent" to read "0.05 max. per cent."

Grade P6.—Change the phosphorus content from "0.025 max. per cent" to read "0.03 max. per cent"; also change the sulfur content from "0.025 max. per cent" to read "0.03 max. per cent."

Grades P8 and P9.—Change the silicon content from "0.70 max. per cent" to read "0.75 max. per cent."

Change footnote "a" to the table to read as follows by the addition of the italicized word and the omission of the words in brackets:

Either molybdenum or tungsten [may] ***shall*** be used [if desired].

Add the following as a footnote to Section 6:

The list is incomplete and will be reviewed annually and revised promptly when necessary.

Tentative Specifications for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for Service at Temperatures from 750 to 1100 F. (A 182 - 35 T):

Section 8.—In the tabulation of chemical requirements make the following changes in Grades F1, F3, F4, F5, F7 and F11:

Grade F1.—Change the sulfur content from "0.045 max. per cent" to read "0.05 max. per cent."

Grade F3.—Change the sulfur content from "0.04 max. per cent" to read "0.05 max. per cent."

Grade F4.—Change the phosphorus content from "0.05 max. per cent" to read "0.04 max. per cent"; also change the manganese content from "0.40 to 0.70 per cent" to read "0.50 to 0.80 per cent"; also change the chromium content from "0.55 to 0.85 per cent" to read "0.50 to 0.80 per cent."

Grade F5.—Change the phosphorus content from "0.04 max. per cent" to read "0.03 max. per cent"; also change the sulfur content from "0.04 max. per cent" to read "0.03 max. per cent"; also change the molybdenum content from "0.40 to 0.60 per cent" to read "0.45 to 0.65 per cent"; also change the tungsten content from "0.80 to 1.25 per cent" to read "0.75 to 1.25 per cent."

Grade F7.—Change the carbon content from "0.25 to 0.40 per cent" to read "0.25 to 0.35 per cent"; also change the manganese content from "0.40 to 0.85 per cent" to read "0.40 to 0.60 per cent"; also change the phosphorus content from "0.05 max. per cent" to read "0.04 max. per cent"; also change the chromium content from "0.75 to 1.10 per cent" to read "0.80 to 1.10 per cent."

Grade F11.—Change the phosphorus content from "0.05 max. per cent" to read "0.04 max. per cent."

The tentative revision of the Standard Specifications for Steel for Bridges (**A** 7 – 34), as amended, was unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote, with the following change in Section 1 of the specifications, presented on the floor at the annual meeting, subject to favorable letter ballot of Committee A-1:[1]

Section 1 (*a*).—Change to read as follows by the addition of the italicized words and figures and the omission of the words in brackets:

1 (*a*) Steel Castings.—The [Standard] *Tentative* Specifications for Carbon Steel Castings *for Miscellaneous Industrial Uses* (A.S.T.M. Designation: A 27 – *36 T*) of the American Society for Testing Materials, shall govern the purchase of steel castings for bridges. Unless otherwise specified, [class B castings, medium grade] *Grade B-1 castings, fully annealed,* shall be used.

The tentative revisions of the Standard Specifications for Steel for Buildings (A 9 – 34), as amended, and for Structural Silicon Steel (A 94 – 33), as amended, were unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote.

The tentative revisions of the Standard Specifications for Open-Hearth Carbon-Steel Rails (A 1 – 30), for Structural Rivet Steel (A 141 – 33), for Structural Steel for Ships (A 131 - 33), for Carbon-Steel Bars for Railway Springs with Special Silicon Requirements (A 68 – 27), for Carbon-Steel Car and Tender Axles (A 21 – 27), as amended, for Quenched-and-Tempered Carbon-Steel Axles, Shafts and Other Forgings for Locomotives and Cars (A 19 – 27), as amended, for Quenched-and-Tempered Alloy-Steel Axles, Shafts and Other Forgings for Locomotives and Cars (A 63 – 27), as amended, for Wrought Solid Carbon-Steel Wheels for Electric Railway Service (A 25 – 24), for Welded and Seamless Steel Pipe (A 53 – 33), for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 – 34), as amended, for Boiler Rivet Steel and Rivets (A 31 – 24), for Commercial Quality Hot-Rolled Bar Steels (A 107 – 33), as amended, for Commercial Cold-Finished Bar Steels and Cold-Finished Shafting (A 108 – 33), as amended, for Carbon-Steel Castings for Valves, Flanges and Fittings for High-Temperature Service (A 95 – 33) and for Forged or Rolled Steel Pipe Flanges for High-Temperature Service (A 105 – 33) were approved for reference to letter ballot of the Society for adoption as standard.

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[1] This recommendation was submitted to letter ballot of Committee A-1 which consists of 206 members 144 members returned their ballots, of whom 82 have voted affirmatively and none negatively.

The withdrawal of the Standard Specifications for High-Carbon-Steel Splice Bars (A 5 – 14), for Quenched High-Carbon-Steel Splice Bars (A 49 – 21), for Quenched Carbon-Steel Track Bolts (A 50 – 33), for Quenched Alloy Steel Track Bolts (A 51 – 33), for Structural Nickel Steel (A 8 – 29), for Carbon-Steel Castings (A 27 – 24), for Carbon Tool Steel (A 71 – 26), for Alloy Tool Steel (A 115 – 28) and for High-Speed Tool Steel (A 92 – 26) was approved.

A paper entitled "Failure of Suspension Bridge Cable Wire," by W. H. Swanger and G. F. Wohlgemuth, was presented from manuscript by Mr. Swanger and discussed.

The report of the Joint Committee on Investigation of the Effect of Phosphorus and Sulfur in Steel was presented from manuscript by the chairman, H. S. Rawdon.

The meeting then adjourned till 8 p. m.

TWELFTH SESSION—THURSDAY, JULY 2, 9.30 A. M.

Cement, Lime, Aggregates

(Held Simultaneously with Eleventh Session)

Vice-President A. C. Fieldner in the chair.

The report of Committee C-1 on Cement was presented by the chairman, P. H. Bates.

The Tentative Specifications for High-Early-Strength Portland Cement (C 74 – 30 T), revised as preprinted in the report, were recommended for adoption as standard with the following additional changes, presented on the floor at the annual meeting, subject to favorable letter ballot of Committee C-1:[1]

Section 1.—Delete from the revised specifications as preprinted the definition which reads as follows:

> 1. High-early-strength portland cement is the product obtained by finely pulverizing clinker, produced by calcining to incipient fusion certain intimate mixtures of finely ground materials containing the elements commonly found in limestones and clays, and to which nothing has been added subsequent to calcination except water and calcined or uncalcined natural gypsum or anhydrite.

Section 2.—At the end of this section add the following statement and note:

> Portland cement is the product obtained by pulverizing clinker consisting essentially of calcium silicates, to which no additions have been made subsequent to calcination other than water and/or untreated calcium sulfate except that additions not to exceed 1 per cent of other materials may be added, provided such materials have been shown not to be harmful by tests prescribed and carried out by Committee C-1 on Cement.
>
> NOTE.—Tests to determine whether a proposed addition is harmful will be carried out by Committee C-1 on Cement, for those making requests, through its Cement Reference Laboratory or other laboratory which the committee may select. As such tests are completed the committee will make known those additions which have been found not to be harmful. (For details regarding the conditions under which the tests will be made, address Technical Assistant, Committee C-1, Cement Reference Laboratory, National Bureau of Standards, Washington, D. C.)

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[1] Committee C-1 reported the following results on this recommendation of a total of 65¾ ballots returned from a committee membership of 72: Revision of specifications, affirmative 57¾, negative 6, ballots marked "not voting" 2; Adoption of revised specifications as standard, affirmative 54¾, negative 10; ballots marked "not voting" 1.

Section 7.—Change this section on Packaging and Marking from its present form: namely,

> 7. The cement shall be delivered in packages as specified with the brand and name of the manufacturer plainly marked thereon, unless shipped in bulk. When shipped in bulk, this information shall be contained in the shipping advices accompanying the shipment. A bag shall contain 94 lb. net. A barrel shall contain 376 lb. net. All packages shall be in good condition at the time of inspection.

to read as follows:

> 7. When, as specified, the cement is delivered in packages the name and brand of the manufacturer of the cement and the nature and amount of the material (found not to be harmful by Committee C-1 on Cement) added to the clinker other than water and/or untreated calcium sulfate shall be plainly marked thereon. When, as specified, the cement is delivered in bulk shipments this information shall be contained in the shipping advices accompanying the shipment. A bag shall contain 94 lb. net. A barrel shall contain 376 lb. net. All packages shall be in good condition at the time of inspection.

On motion this recommendation, after discussion, was unanimously approved and the tentative specifications, as further revised, were unanimously approved for reference to letter ballot of the Society for adoption as standard, the provision for testing cement containing additions being subject to review by the Executive Committee of the Society.[1]

It was announced that the committee had decided to withdraw its recommendation, which appeared in the report as preprinted, for the publication as tentative of Specifications for High-Early-Strength Treated Portland Cement[2] since separate specifications would not be necessary in view of the additional changes proposed in the Tentative Specifications C 74 – 30 T, as recorded above.

A paper entitled "Effect of Departure from Planeness of Bearing Surfaces on the Compressive Strength of Two-Inch Mortar Cubes," by J. R. Dwyer, was presented from manuscript by the author.

A paper entitled "A Hydrometer Method for Determining the Fineness of Portland-Puzzolan Cements," by S. B. Biddle Jr. and Alexander Klein, was presented by G. E. Troxell and discussed.

A paper entitled "The Influence of Low Curing Temperatures on the Hardening of Cement Mortars," by S. A. Mironoff, was presented from manuscript by J. C. Pearson and discussed.

A paper entitled "Petrographic Studies of Hydrated Cements," by L. S. Brown and R. W. Carlson, was presented from manuscript by Mr. Brown and discussed.

The report of Committee C-7 on Lime was presented by the secretary Lee S. Trainor. The proposed Tentative Specifications for Sand for Use in Plaster, prepared under the joint cooperation of Committee C-7 and Committee C-11 on Gypsum, were accepted for publication as tentative to replace the existing Tentative Specifications for Sand for Use in Lime Plaster (C 66 – 31 T) under the jurisdiction of Committee C-7 and the Standard Specifications for Sand for Use in Gypsum Plaster (C 35 – 30) under the jurisdiction of Committee C-11. The withdrawal of the Tentative Specifications C 66 – 31 T and the Standard Specifications C 35 – 30 was accordingly approved.

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[1] The Executive Committee at its October, 1936, meeting approved these specifications as revised.

[2] The proposed withdrawal of these specifications was submitted to letter ballot of Committee C-1 which consists of 72 members, of the 65½ ballots returned the results were as follows: Affirmative 59½, negative 4, ballots marked "not voting" 2.

The recommended revision of the Tentative Methods of Physical Test for Limestone, Quicklime and Hydrated Lime (C 110 – 34 T) which appeared in the report as preprinted, involving a proposal to delete from the methods the autoclave test for soundness and to substitute therefor the test for constancy of volume, was discussed. On motion, this recommendation was referred back to Committee C-7 on Lime for further consideration, the autoclave test to be retained in the Tentative Methods C 110 – 34 T until this matter had been given further study by the committee.

A paper entitled "The Cone Method for Determining the Absorption by Sand," by D. O. Woolf, was presented by the author and discussed.

A paper entitled "Elastic and Thermal Expansion Properties of Concrete as Affected by Similar Properties of the Aggregate," by L. H. Koenitzer, was presented by C. H. Scholer.

The meeting then adjourned till 8 p. m.

THIRTEENTH SESSION—THURSDAY, JULY 2, 8 P. M.

Concrete, Road and Paving Materials, Soils

(Held Simultaneously with Fourteenth Session)

Mr. P. H. Bates in the chair.

The report of Committee C-9 on Concrete and Concrete Aggregates was presented by the chairman, R. W. Crum. The Tentative Method of Test for Flow of Portland-Cement Concrete by Use of the Flow Table, the Laboratory Method of Making Flexure Tests of Concrete Using a Simple Beam with Third Point Loading as a revision of and to replace the existing Tentative Method C 78 – 30 T, and Method of Test for Coal and Lignite in Sand were accepted for publication as tentative.

The Tentative Definitions of Terms Relating to Concrete and Concrete Aggregates were accepted for publication as tentative with the following change in the definition of "crushed gravel," presented on the floor at the annual meeting, subject to favorable letter ballot of Committee C-9:[1]

Crushed Gravel.—Change the definition of this term as preprinted to read as follows by the addition of the italicized words and the omission of those in brackets:

> *Crushed Gravel.*—The product resulting from the artificial crushing of gravel with [each fragment] *substantially all fragments* having at least one face resulting from fracture.

The proposed revision of the Tentative Specifications for Concrete Aggregates (C 33 – 31 T) was accepted, the specifications as revised being continued as tentative. The revisions proposed for immediate adoption in the Standard Specifications for Curing Portland-Cement Concrete Slabs with Bituminous Coverings (C 81 – 34), for Curing Portland-Cement Concrete Slabs with Wet Coverings (C 84 – 34) and for Curing Portland-Cement Concrete Slabs by Surface Application of Calcium Chloride (C 83 – 34) were unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote.

The Tentative Methods of Making Compression Tests of Concrete Using Portions of Beams Broken in Flexure (C 116 – 35 T), Test for Structural Strength of Fine Aggregate Using Constant Water-Cement Ratio Mortar (C 87 – 32 T), for Absorption by Aggregates for Concrete (Laboratory Determinations) (C 95 – 33 T), Field Test for Absorption of Mixing Water by Aggregates for Concrete (C 96 – 33 T) and Specifications for Sodium Silicate for Curing Concrete (C 111 – 34 T) were approved for reference to letter ballot of the Society for adoption as standard.

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[1] This recommendation was submitted to letter ballot of Committee C-9 which consists of 61 members; 33 members returned their ballots, of whom 30 have voted affirmatively and 1 negatively.

The recommendation, presented on the floor at the annual meeting, that the Tentative Method of Routine Analysis of the Cement Content of Hardened Portland-Cement Concrete (C 85 – 31 T) be approved for reference to letter ballot of the Society for adoption as standard was unanimously approved, subject to favorable letter ballot of Committee C-9.[1]

The tentative revision of the Standard Method of Test for Sieve Analysis of Aggregate for Concrete (C 41 – 33) was approved for reference to letter ballot of the Society for adoption as standard. The withdrawal of the Tentative Method of Making Flexure Tests of Concrete Using a Simple Beam with Center Loading (C 78 – 30 T), which was being replaced by the revised method mentioned above, was approved.

In presenting the report Mr. Crum called attention to the paper entitled "Apparatus and Technique for the Concrete Permeability Tests of the Bureau of Reclamation," by E. N. Vidal and G. A. Samson, which had been accepted by the committee for inclusion in its annual report, but had not been preprinted. Mr. Crum called upon Fred Hubbard to present from manuscript the paper on "Studies on Relation Between Characteristics of Blast-Furnace Slag and Other Coarse Aggregates and Properties of Resultant Concretes," which was not included in the report as preprinted. Mr. Crum then called upon Mr. Walker to present from manuscript the paper entitled "Progress Report on Studies of Sodium and Magnesium Sulfate Soundness Tests," by Stanton Walker and C. E. Proudley, which was not included in the report as preprinted. After discussion of this paper, Mr. Crum requested Mr. Richart to present the paper entitled "Shrinkage of Haydite and Sand-Gravel Concrete," by F. E. Richart and J. E. Keranen.

A verbal progress report of the Joint Committee on Concrete and Reinforced Concrete was presented by the vice-chairman, F. E. Richart.

A paper entitled "Rating the Characteristics of Fresh Concrete," by Harmer E. Davis and J. W. Kelly, was presented from manuscript by G. E. Troxell and discussed.

A paper entitled "The Effect of Testing Speed on Strength and Elastic Properties of Concrete," by Paul G. Jones and F. E. Richart, was presented by Mr. Richart and discussed.

Mr. R. W. Crum then assumed the chair.

The report of Committee D-4 on Road and Paving Materials was presented by the vice-chairman, A. T. Goldbeck. The editorial changes in the Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (D 6 – 33) were accepted. The Tentative Method of Test for Residue of Specified Penetration (D 243 – 35 T) was approved for reference to letter ballot of the Society for adoption as standard.

The recommendation presented jointly by Committee D-4 and Committee D-8 on Bituminous Waterproofing and Roofing Materials that Group 0 and Group 1 in the Standard Abridged Volume Correction Table for Petroleum Oils (D 206 – 34) be formally approved by the Society as standard as a volume correction table for asphaltic products, was accepted.

The Tentative Method of Test for Separation of Liquid Asphaltic Products (D 402 – 34 T) was approved for reference to letter ballot of the Society for adoption as standard, with the following editorial modifications, presented on the floor at the annual meeting.

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[1] This recommendation was submitted to letter ballot of Committee C-9 which consists of 61 members; 33 members returned their ballots, of whom 27 have voted affirmatively and 2 negatively.

Section 12 (*a*).—In connection with the size of sample prescribed in the first sentence of this section for the distillation test, namely, 200 ml., add the following as a footnote:

> **In the case of persistently foaming material, one-half of this amount may be employed.**

Section 12 (*b*).—In order to avoid possible misunderstanding as to the intent of this section it is recommended that the word "uniformity" be substituted for "homogeneity."

It was announced that the committee had decided to withdraw from its report as preprinted the recommendation for the withdrawal of the existing Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (D 36 - 26).

It was announced that Committee D-4 contemplates extensive revisions in certain of its standard specifications and it was accordingly recommended on the floor at the annual meeting that the following standard specifications be reverted to the tentative status:

Standard Specifications for:

High-Carbon Tar for Surface Treatment, Cold Application (D 104 - 30),
Low-Carbon Tar for Surface Treatment, Cold Application (D 105 - 30),
High-Carbon Tar for Surface Treatment, Hot Application (D 108 - 30),
Low-Carbon Tar for Surface Treatment, Hot Application (D 109 - 30),
High-Carbon Tar Cement (D 110 - 30), and
Low-Carbon Tar Cement (D 111 - 30).

The above recommendation was unanimously approved, subject to favorable letter ballot of Committee D-4.[1]

Because it is considered as unnecessary and misleading in connection with its title, it was recommended that the Tentative Specifications for Emulsified Asphalt (Heavy Premix—Winter Grade) (D 400 - 34 T) be withdrawn. This recommendation was approved, subject to favorable letter ballot of Committee D-4.[1]

The revisions, recommended on the floor at the annual meeting, in the following four tentative specifications were unanimously approved, subject to favorable letter ballot of Committee D-4:[1]

Tentative Specifications for Emulsified Asphalt (*for Coarse Aggregate Plant Mixes* (*D 397 - 34 T*):

Section 1 (*b*).—Change the requirement for viscosity and miscibility with water to read as follows by the omission of the words and figures in brackets and the addition of the italicized word:

Viscosity, Saybolt Furol, 60 ml. at 25 C. (77 F.)	not less than 100 sec., [and] [not more than 700 sec.]
Miscibility with water	no appreciable [separation] *coagulation* in 2 hr.

Section 1 (*c*).—Change the present requirement for percentage soluble in carbon disulfide now specified as "not less than 95 per cent" to read "not less than 97.5 per cent for petroleum asphalts or 95 per cent for native asphalts."

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[1] The letter ballots on these recommendations were favorable and the results are given in detail on page 431.

Tentative Specifications for Emulsified Asphalt (for Retread and Coarse Aggregate Mixes) (D 398 – 34 T) and for Emulsified Asphalt (Heavy Premix—Summer Grade) (D 399 – 34 T):

Section 1 (b).—In the requirement for miscibility with water, change the word "separation" to read "coagulation."

Section 1 (c).—Make the same change in the requirement for percentage soluble in carbon disulfied in this section as recommended in Section 1 (*c*) of Specifications D 397 – 34 T, above.

Tentative Specifications for Emulsified Asphalt ((Quick-Setting) for Penetration and Surface Treatment) (D 401 – 34 T):

Section 1 (b).—Change the requirement for demulsibility (35 ml. of 0.02 *N* $CaCl_2$) from "not less than 50 per cent" to read "not less than 60 per cent."

Section 1 (c).—Make the same change in the requirement for percentage soluble in carbon disulfide in this section as recommended in Section 1 (*c*) of Specifications D 397 – 34 T, above.

A paper entitled "Internal Stability of Granular Materials," by William S. Housel, was presented by the author and discussed.

A paper entitled "Testing and Design of Stabilized Soil Mixtures," by C. A. Hogentogler, Jr., was presented from manuscript by the author and discussed.

The meeting then adjourned till the following morning.

FOURTEENTH SESSION—THURSDAY, JULY 2, 8 P. M.

Rubber and Textiles

(Held Simultaneously with Thirteenth Session)

President H. S. Vassar in the chair.

The report of Committee D-13 on Textile Materials was presented by the chairman, H. J. Ball. The Tentative Methods of Testing and Tolerances for Certain Carded Cotton Gray Goods, for Resistance to Yarn Slippage in Silk, Rayon, and Silk-Rayon Woven Broad Goods, for Fastness of Dyed or Printed Cotton Fabrics to Laundering or Domestic Washing, and for Fastness of Dyed or Printed Silk or Rayon Fabrics to Laundering or Domestic Washing were accepted for publication as tentative.

The recommendation that the Method of Test for Shrinkage and Laundering, appearing in Sections 14 to 21 of the Standard General Methods of Testing Woven Textile Fabrics (D 39 – 34) be issued as a separate standard under the title "Standard Method of Test for Shrinkage in Laundering of Woven Cotton Cloth," was unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote.

The proposed revisions of the Tentative Definitions and Terms Relating to Textile Materials (D 123 – 35 T) and Methods of Testing and Tolerances for Silk and Cotton Tapes (D 259 – 31 T), Test for Small Amounts of Copper and Manganese in Textiles (D 377 – 33 T) and Testing Pile Floor Covering (D 418 – 35 T) were accepted, the definitions and methods, as revised, being continued as tentative.

The revisions proposed for immediate adoption in the Standard General Methods of Testing Woven Textile Fabrics (D 39 – 34), Methods of Testing and Tolerances for Cotton Yarns, Single and Plied (D 180 – 33), for Cotton Sewing Threads (D 204 – 33), Specifications and Methods of Test for Asbestos Tape for Electrical Purposes

(D 315 – 33), Specifications for 0.007-in. Cotton Tape for Electrical Purposes (D 335 – 34) and Methods of Testing and Tolerances for Certain Light and Medium Cotton Fabrics (D 274 – 34) were unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote.

The Tentative Methods of Estimating Hard Scoured Wool in Wool in the Grease (D 232 – 35 T), Testing and Tolerances for Tubular Sleeving and Braids (D 354 – 35 T), for Woolen Yarns (D 403 – 35 T), for Worsted Yarns (D 404 – 35 T), Specifications for Textile Testing Machines (D 76 – 35 T), as revised, to replace the existing Standard Specifications D 76 – 33, Specifications and Methods of Test for Asbestos Yarns (D 299 – 34 T), as revised to replace the existing Standard Specifications D 299 – 33, and for Asbestos Roving for Electrical Purposes (D 375 – 34 T), as revised, were approved for reference to letter ballot of the Society for adoption as standard. The tentative revision of the Standard Methods of Testing and Tolerances for Hose Ducks and Belt Ducks (D 181 – 34) was approved for reference to letter ballot of the Society for adoption as standard. The withdrawal of the Standard Methods of Testing and Tolerances for Electrical Cotton Yarns, Single and Plied (D 203 – 33), Specifications and Methods of Test for Asbestos Yarns (D 299 – 33) and Specifications for Textile Testing Machines (D 76 – 33) was approved, the latter two being replaced by revised specifications as mentioned above.

It was announced that since the preparation of the test for acidity, proposed for inclusion in the Tentative Methods D 259 – 31 T, it has developed that there is available an improved type of apparatus for this test, and the proposed description of the test apparatus will be revised editorially to cover the new instrument.

The report of Committee D-11 on Rubber Products was presented by the chairman, H. A. Depew. The proposed revisions of the Tentative Specifications and Tests for Friction Tape for General Use for Electrical Purposes (D 69 – 35 T), Method of Test for Compression Set of Vulcanized Rubber (D 395 – 34 T), Test for Adhesion of Vulcanized Rubber (Friction Test) (D 413 – 35 T), for Accelerated Aging of Vulcanized Rubber (D 428 – 35 T), and for Adhesion of Vulcanized Rubber to Metal (D 429 – 35 T) were accepted, the specifications and methods as revised being continued as tentative.

The proposed revisions of the Tentative Methods of Tension Testing of Vulcanized Rubber (D 412 – 35 T) were accepted with the following additional changes approved by letter ballot[1] of Committee D-11, which were presented on the floor at the annual meeting and unanimously approved:

Section 4.—Add the following as a new Paragraph (*f*):

> (*f*) The testing machine shall be calibrated in accordance with the provisions of Section 6.

New Section.—Add the following as a new Section 6, renumbering the remaining sections accordingly:

> 6. *Calibration of Tension Testing Machines.*—Tension testing machines shall be calibrated by dead-weights applied in an ascending order while the machine is otherwise arranged in an entirely similar manner to that used when testing material. In each case when additional calibrating weight is added the weight lever of the machine shall be moved to zero position and allowed to swing slowly upwards to the point where it will go no further. The dial of the machine should then clearly indicate the amount of the weight applied.

The revisions proposed for immediate adoption in the Standard Methods of Chemical Analysis of Rubber Products (D 297 – 32) were unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote. The Tentative Methods of Testing Rubber Belting Used for Power Transmission (D 378 – 33 T), Braided Hose (D 379 – 33 T) and Wrapped Rubber Hose (D 380 – 33 T) were approved for reference to letter ballot of the Society for adoption as standard.

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[1] The proposed revision was submitted to letter ballot of Committee D-11 which consists of 83 members; 29 members returned their ballots, of whom 26 voted affirmatively and 1 negatively.

It was announced that the committee had completed certain revisions in two of the tentative specifications for insulated wire and cable which would be presented to the Society through Committee E-10 on Standards subsequent to the annual meeting.

The chairman in introducing the Symposium on the Limitations of Laboratory and Service Tests in Evaluating Rubber Products, stated that it had been arranged under the auspices of Committee D-11 on Rubber Products for the purpose of showing the use of laboratory tests in evaluating rubber products as to performance, and as a guide for purchase specifications, and to give some indication as to how far it may be necessary to rely on service experience. The following five papers comprising the symposium were then presented:

"Methods of Evaluating Tire Performance," by R. D. Evans, presented by the author.

"The Testing of Rubber Footwear," by W. E. Glancy, presented by the author.

"Significance of Laboratory Tests in Evaluating Automotive Rubber Parts," by J. J. Allen, presented from manuscript by the author and discussed.

"The Relation Between Laboratory Tests and Service Life of Rubber Hose and Belting," by W. L. Smith and Arthur W. Carpenter, presented from manuscript by Mr. Carpenter.

"The Testing of Rubber Insulated Wires and Cables," by Dean Harvey, presented by the author and discussed.

The meeting then adjourned till the following morning.

FIFTEENTH SESSION—FRIDAY, JULY 3, 9.30 A. M.

Bituminous Materials

(Held Simultaneously with Sixteenth Session)

Mr. C. S. Reeve in the chair.

The report of Committee D-8 on Bituminous Waterproofing and Roofing Materials was presented by the chairman, J. M. Weiss. In presenting the report Mr. Weiss called upon Mr. Greider to present the paper entitled "A Comparison of Abrasion Test Methods for Embedding of Granular Mineral Surfacing on Asphalt Roofing," by H. W. Greider and G. A. Fasold.

The recommendation presented jointly by Committee D-8 and Committee D-4 on Road and Paving Materials that Group 0 and Group 1 in the Standard Abridged Volume Correction Table for Petroleum Oils (D 206 – 34) be formally approved by the Society as standard as a volume correction table for asphaltic products, was accepted.

Attention was called to a change in the report as preprinted concerning a proposed correction in the specified value for penetration of mineral surfaced flat type roofing in the Tentative Specifications for Asphalt for Use in Constructing Built-Up Roof Coverings (D 312 – 35 T). This proposed change was eliminated from the report.

It was announced that Committee D-8 contemplates extensive revisions in certain of its standard specifications and it was accordingly recommended on the floor at the annual meeting that the following standard specifications be reverted to the tentative status:

Standard Specifications for:

High-Carbon Coal-Tar Pitch for Use in Damp-proofing and Waterproofing Below Ground Level (D 42 – 25),
High-Carbon Coal-Tar Pitch for Use in Damp-proofing and Waterproofing Above Ground Level (D 145 – 25),
High-Bitumen Coal-Tar Pitch for Use in Damp-proofing and Waterproofing Below Ground Level (D 200 – 25),
High-Bitumen Coal-Tar Pitch for Use in Damp-proofing and Waterproofing Above Ground Level (D 201 – 25),
High-Carbon Coal-Tar Pitch for Use in Constructing Built-Up Roofs, Surfaced with Slag or Gravel (D 251 – 27),
High-Bitumen Coal-Tar Pitch for Use in Constructing Built-Up Roofs Surfaced with Slag or Gravel (D 252 – 27),
Asphalt for Use in Damp-proofing and Waterproofing Below Ground Level (D 40 – 25),
Asphalt for Use in Damp-proofing and Waterproofing Above Ground Level (D 144 – 25),
Creosote for Priming Coat with Coal-Tar Pitch in Damp-proofing and Waterproofing Below and Above Ground Level (D 43 – 25), and
Primer for Use with Asphalt in Damp-proofing and Waterproofing Below and Above Ground Level (D 41 – 26).

The above recommendation was unanimously approved, subject to favorable letter ballot of Committee D-8.[1]

The following editorial revisions of the Tentative Methods of Testing Emulsified Asphalt (D 244 – 35 T), presented on the floor at the annual meeting, were unanimously approved.

Section 8 (e).—Change the last sentence to read as follows by the addition of the italicized words and figure:

> The end of the condenser to be inserted in the trap shall be ground off at an angle of 30 deg. ***plus or minus 5 deg.*** from the vertical axis of the condenser.

Section 8 (f).—To conform with the request of Committee E-1 on Methods of Testing in the standardization of apparatus and without in any way affecting the procedure or value of the test, it is proposed that this section be changed from its present form: namely,

> (*f*) ***Trap.***—The trap shall be made of well-annealed glass constructed in accordance with Fig. 3 (*c*) and shall be graduated from 0 to 25 ml. The tube shall be graduated from 0 to 2 ml. in 0.1 ml., from 2 to 5 ml. in 0.2 ml., and from 5 to 25 ml. in 0.5 ml. The outside diameters should be preferably 2.5 to 3.5 mm. ($\frac{3}{32}$ to $\frac{1}{8}$ in.) greater than the inside diameters specified.

to read as follows:

> (*f*) ***Trap.***—The trap shall be made of well-annealed glass constructed in accordance with Fig. 3 (*c*) (the accompanying Fig. 1) and shall be graduated from 0 to 25 ml., in 0.1 ml. divisions. The tolerance of the graduations between 0 and 2 ml. shall be ± 0.5 ml. and between 2 and 25 ml. shall be ± 0.1 ml.

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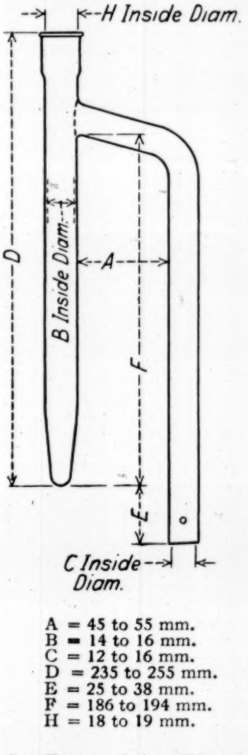
[1] **The letter ballots on these recommendations were favorable and the results are given in detail on page 450.**

Fig. 3 (*c*).—Replace the present illustration in Fig. 3 (*c*) with the accompanying Fig. 1.

A paper entitled "The Effect of Mineral Fillers on the Serviceability of Coating Asphalts," by O. G. Strieter, was presented by the author and discussed.

A paper entitled "A Further Study of the Heterogeneity of Asphalt—a Quantitative Method," by G. L. Oliensis, was presented by the author and discussed.

A paper entitled "Measurement of High Viscosity—a Rapid Method," by R. N. Traxler and H. E. Schweyer, was presented by Mr. Traxler and discussed.



A = 45 to 55 mm.
B = 14 to 16 mm.
C = 12 to 16 mm.
D = 235 to 255 mm.
E = 25 to 38 mm.
F = 186 to 194 mm.
H = 18 to 19 mm.

FIG. 1.—Trap for Test for Determining Water in Emulsified Asphalts.

Mr. J. M. Weiss then assumed the chair.

A paper entitled "The Susceptibility of Asphalts to Temperature Change," by H. E. Schweyer, C. E. Coombs and R. N. Traxler, was presented by Mr. Traxler and discussed.

A paper entitled "Increase in Viscosity of Asphalts with Time," by R. N. Traxler and H. E. Schweyer, was presented by Mr. Traxler and discussed.

A paper entitled "Compression Testing of Asphalt Paving Mixtures," by Roland Vokac, was presented by the author and discussed.

The meeting then adjourned till 2 p. m.

SIXTEENTH SESSION—FRIDAY, JULY 3, 9.30 A. M.

Non-Ferrous Metals, Metallography

(Held Simultaneously with Fifteenth Session)

Mr. J. R. Townsend in the chair.

The report of Committee B-1 on Copper and Copper Alloy Wires for Electrical Conductors was presented by the chairman, J. A. Capp. The proposed Tentative Specifications for Hard-Drawn Copper Alloy Wires for Electrical Conductors were accepted for publication as tentative. The Tentative Specifications for Bare Stranded Copper Cable: Hard, Medium-Hard or Soft (B 8 – 35 T), as revised, and for Bronze Trolley Wire (B 9 – 35 T), to replace the existing standards, were approved for reference to letter ballot of the Society for adoption as standard. The tentative revision of the Standard Specifications for Copper Trolley Wire (B 47 – 32) was approved for reference to letter ballot of the Society for adoption as standard.

A paper entitled "Effect of Time on Tensile Properties of Hard Drawn Copper Wire," by Albert J. Phillips and A. A. Smith, Jr., was presented from manuscript by Mr. Smith and discussed.

The report of Committee B-5 on Copper and Copper Alloys, Cast and Wrought, was presented by the chairman, C. H. Mathewson. The Tentative Specifications for Seamless Copper-Nickel Alloy Condenser Tubes and Ferrule Stock, for Sheet and Strip Phosphor Bronze, for Bronze Castings in the Rough for Locomotive Wearing Parts, and for Car and Tender Journal Bearings, Lined, the latter two specifications to replace existing standards, were accepted for publication as tentative. The Tentative Specifications for Bronze Castings for Turntables and Movable Bridges (B 22 – 36 T) were accepted for publication as tentative to replace the existing standard, with the following change in Section 1 (*b*) presented on the floor at the annual meeting, subject to favorable letter ballot of Committee B-5:[1]

Section 1 (*b*).—Change the second paragraph to read as follows by the addition of the italicized figures and the omission of those in brackets:

> *Class B.*—For contact with hardened steel disks at low speeds under pressures not over [2000] *2500* lb. per sq. in., for example, disk bearing metals used in turntable and center-bearing swing bridges and for contact with steel (tensile strength 60,000 lb. per sq. in., min.) at low speeds under pressures not over 1500 lb. per sq. in., for example, trunnions of movable bridges.

Section 4 (*a*).—Change the first sentence to read as follows by the omission of the words in brackets:

> An analysis of each melt may be made at the option of the purchaser [and at the purchaser's expense].

The proposed revisions of the Tentative Specifications for Copper-Silicon Alloy Plates and Sheets (B 96 – 34 T), for Sheet Copper-Silicon Alloy (B 97 – 34 T) and for Copper-Silicon Alloy Wire for General Purposes (B 99 – 35 T) were accepted, the specifications as revised being continued as tentative. It was announced that further revisions of these specifications were in preparation and that these would be submitted to the Society through Committee E-10 on Standards subsequent to the annual meeting.

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[1] This recommendation was submitted to letter ballot of Committee B-5 which consists of 55 members; 45 members returned their ballots, of whom 36 have voted affirmatively and none negatively.

The revision proposed for immediate adoption in the Standard Specifications for Aluminum-Bronze Castings (B 59 – 28) was unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote, subject to favorable letter ballot of Committee B-5.[1]

The revisions proposed for immediate adoption in the Standard Specifications for Steam or Valve Bronze Sand Castings (B 61 – 28) were unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote, with the following additional change presented on the floor at the annual meeting, subject to favorable letter ballot of Committee B-5:[2]

Section 1.—Add the following as a footnote in connection with this revised section on scope:

> The temperature recommendation of the scope clause is conservative in view of known design practice. Establishment of definite limiting design stresses and of dimensional standards later may possibly permit some raising of the limiting temperature above that now recommended.

The proposed revisions of the Standard Specifications for Manganese-Bronze Ingots for Sand Castings (B 7 – 27) and for Manganese-Bronze Sand Castings (B 54 – 27) were accepted for publication as tentative.

The Tentative Specifications for Copper-Base Alloys in Ingot Form for Sand Castings (B 30 – 32 T) were approved for reference to letter ballot of the Society for adoption as standard.

The tentative revisions of the Standard Specifications for Sand Castings of the Alloy: Copper 88 per cent; Tin 8 per cent; Zinc 4 per cent (B 60 – 28), for Steam or Valve Bronze Sand Castings (B 61 – 28), and for Composition Brass or Ounce Metal Sand Castings (B 62 – 28) were approved for reference to letter ballot of the Society for adoption as standard.

The withdrawal of the Standard Specifications for Bronze Bearing Metals for Turntables and Movable Railroad Bridges (B 22 – 21), for Bronze Castings in the Rough for Locomotive Wearing Parts (B 66 – 28) and for Car and Tender Journal Bearings, Lined (B 67 – 28) was approved.

A paper entitled "Flexure and Torsion Testing of Copper Wire," by S. E. Borgeson, was presented by the author and discussed.

The report of Committee B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys was presented by the chairman, Dean Harvey. The Tentative Method of Test for Deflectivity of Thermoflex (Thermostatic Metals) was accepted for publication as tentative.

The revisions proposed for immediate adoption in the Standard Methods of Test for Resistivity of Metallic Materials for Resistors (B 63 – 29), for Determining the Temperature-Resistance Constants of Resistance Alloys (B 84 – 34) and Accelerated Life Test for Metallic Materials for Electrical Heating (B 76 – 33) were unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote. The editorial changes in the Standard Method of Test for Thermoelectric Power of Electrical-Resistance Alloys (B 77 – 33) were accepted. The Proposed Method for the Bend Testing of Wire was accepted for publication as information in an appendix to the report.

The chairman recognized F. E. Bash who presented an introduction to the paper entitled "Impact Bend Testing of Wire," by W. J. Farmer and D. A. S. Hale. Mr.

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[1] This recommendation was submitted to letter ballot of Committee B-5 which consists of 55 members; 45 members returned their ballots, of whom 33 have voted affirmatively and none negatively.

[2] This recommendation was submitted to letter ballot of Committee B-5 which consists of 55 members; 45 members returned their ballots, of whom 34 have voted affirmatively and none negatively.

Bash outlined briefly the circumstances leading up to the development of the bendometer and the considerations that had been given to this matter by Committee B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys. The paper was then presented from manuscript by Mr. Hale and discussed. The subject covered by the paper was illustrated by high-speed motion pictures.

The report of Committee E-4 on Metallography was presented by the chairman, C. H. Davis. The revisions proposed for immediate adoption in the Standard Rules Governing the Preparation of Micrographs of Metals and Alloys, Including Recommended Practice for Photography as Applied to Metallography (E 2 – 30) were unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote.

The Tentative Recommended Practice for Metallographic Testing of Ferrous and Non-Ferrous Metals (E 3 – 35 T), as revised, was approved for reference to letter ballot of the Society for adoption to replace the existing Standard Methods of Metallographic Testing of Iron and Steel (E 3 – 24) and of Non-Ferrous Metals and Alloys (E 5 – 27), the withdrawal of which standards was accordingly approved.

The meeting then recessed till 2 p. m., being continued in the Seventeenth Session.

SEVENTEENTH SESSION—FRIDAY, JULY 3, 2 P. M.

Non-Ferrous Metals (*continued*)

(Held Simultaneously with Eighteenth Session)

Mr. C. H. Mathewson in the chair.

The report of Committee B-7 on Light Metals and Alloys, Cast and Wrought, was presented by the chairman, Sam Tour. The Tentative Specifications for Magnesium-Base Alloy Bars, Rods and Shapes were accepted for publication as tentative. The proposed revisions of the Tentative Specifications for Magnesium-Base Alloy Sand Castings (B 80 – 34 T), for Magnesium-Base Alloy Sheet (B 90 – 34 T), for Magnesium-Base Alloy Forgings (B 91 – 34 T), for Magnesium Ingot and Stick for Remelting (B 92 – 33 T) and for Magnesium-Base Alloy Ingot for Remelting (B 93 – 34 T) were accepted, the specifications as revised being continued as tentative.

It was announced that the committee was contemplating submitting to the Society through Committee E-10 on Standards subsequent to the annual meeting new Specifications for Aluminum-Alloy Permanent-Mold Castings and revisions in the Tentative Specifications for Aluminum-Base Alloy Sand Castings (B 26 – 33 T), and in several of the specifications for aluminum-alloy wrought materials.

The report of Committee B-6 on Die-Cast Metals and Alloys was presented by the chairman, J. R. Townsend. In presenting the report Mr. Townsend called attention to the work of Subcommittee I on Aluminum-Base Die-Casting Alloys and stated that the report prepared by J. J. Bowman on "An Investigation of Aluminum Die-Casting Alloys IVa and Va had been accepted by the committee for inclusion in its annual report, but had not been preprinted. Mr. Townsend then called upon J. C. Fox to present his paper entitled "Finishing of Die Castings," which was appended to the report.

The report of Committee B-2 on Non-Ferrous Metals and Alloys was presented by the secretary, E. E. Thum.

A paper entitled "The Effect of the Addition of Lead on the Endurance Limit of a Certain Tin-Base Bearing Alloy," by John N. Kenyon, was presented by the author and discussed.

A paper entitled "Stress-Relief Annealing High-Strength Monel Metal Plate," by Peter R. Kosting, was presented by the author and discussed.

A paper entitled "Effect of Iron Impurities on the Annealing of High Brass," by W. A. Gibson and J. H. Doss, was presented by Mr. Gibson.

A paper entitled "The Forming Properties of Some Non-Ferrous Sheet Metals," by G. R. Gohn, was presented by the author and discussed.

A paper entitled "Ductility Testing of Aluminum and Aluminum Alloy Sheet," by R. L. Templin, was presented by the author and discussed.

The meeting then adjourned.

EIGHTEENTH SESSION—FRIDAY, JULY 3, 2 P. M.

Ceramics, Building Materials, Paint

(Held Simultaneously with Seventeenth Session)

President H. S. Vassar in the chair.

The report of Committee C-3 on Brick was presented by the secretary, J. W Whittemore. In presenting the report Mr. Whittemore called upon J. W. McBurney to present a paper on "Water Absorption of Building Brick," which appeared in an appendix to the report and which after presentation was discussed.

The report of Committee C-18 on Natural Building Stones and Slate was presented by the secretary, H. S. Brightly. The Tentative Methods of Test for Absorption and Apparent Specific Gravity of Natural Building Stone (C 97 – 31 T), of Flexure Testing of Natural Building Stone (Determination of Modulus of Rupture) (C 99 – 31 T), Test for Modulus of Elasticity of Natural Building Stone (C 100 – 31 T), and Shear Testing of Natural Building Stone (C 102 – 31 T) were approved for reference to letter ballot of the Society for adoption as standard. The proposal that the Tentative Definitions of Terms Relating to Natural Building Stone (C 104 – 31 T) be adopted as standard, which appeared in the report as preprinted, was withdrawn.

The report of Committee C-8 on Refractories was presented by J. W. McBurney. The Tentative Method of Panel Test for Resistance to Thermal and Structural Spalling of Super Duty Fireclay Brick was accepted for publication as tentative. The proposed revisions of the Tentative Definitions of Terms Relating to Refractories (C 71 – 35 T) were accepted, the definitions as revised being continued as tentative. The proposed revision of the Standard Definitions for Fireclay Refractories (C 27 – 35) comprising a revised definition of "super duty fireclay brick" was accepted for publication as tentative.

The Tentative Specifications for Clay Fire Brick for Malleable Furnaces with Removable Bungs and for Annealing Ovens (C 63 – 34 T), for Clay Fire Brick for Stationary Boiler Service (C 64 – 34 T), for Ground Fire Clay (C 105 – 34 T), for Refractories for the Construction of Incinerators (C 106 – 34 T), Methods of Panel Test for Resistance of Refractory Brick to Thermal and Structural Spalling (C 38 – 34 T), Test for Particle Size of Ground Refractory Material (C 92 – 34 T), Panel Test for Resistance to Thermal and Structural Spalling of Fireclay Brick for Stationary Boilers and Malleable Iron Furnace Bungs (C 107 – 34 T), Test for Permanent Linear Change After Reheating of Refractory Brick (C 113 – 34 T) were approved for reference to letter ballot of the Society for adoption as standard. The definition of "grog fire-clay mortar" appearing in the Tentative Definitions of Terms Relating to Refractories (C 71 - 35 T) was approved for reference to letter ballot of the Society for adoption as standard. The tentative revision of the Standard Method of Test for Refractory Materials Under Load at High Temperatures (C 16 - 20) was approved for reference to letter ballot of the Society for adoption as standard.

It was announced that the committee is withdrawing the formal approval which it gave in 1932 to the Standard Methods of Testing Brick (Compression, Flexure, Absorption) (C 67 - 31), for use in tests for modulus of rupture or flexural strength of refractories, since the methods have been found not to be entirely suited for testing of refractory brick and a new procedure is being formulated for testing fire brick.

The report of Committee C-10 on Hollow Masonry Building Units was presented by the chairman, D. E. Parsons. The Tentative Specifications and Tests for Load-Bearing Concrete Masonry Units (C 90 - 34 T), as editorially revised, were approved for reference to letter ballot of the Society for adoption as standard.

The Tentative Specifications for Structural Clay Load-Bearing Wall Tile (C 34 - 35 T), as revised, were unanimously approved for reference to letter ballot of the Society for adoption as standard with the following additional modification presented on the floor at the annual meeting, subject to favorable letter ballot of Committee C-10:[1]

Section 3 (a).—Revise by the omission of the requirements for maximum average weight expressed in pounds per square foot of tile which appear in the tabulation following this section.

The Tentative Specifications for Structural Clay Non-Load-Bearing Tile (C 56 - 35 T), as revised, were unanimously approved for reference to letter ballot of the Society for adoption as standard with the following additional modification presented on the floor at the annual meeting, subject to favorable letter ballot of Committee C-10:[2]

Section 3.—Revise by the omission of the requirements for maximum average weight expressed in pounds per square foot of tile which appear in the tabulation following this section.

The Tentative Specifications for Structural Clay Floor Tile (C 57 - 35 T), as revised, Methods of Sampling and Testing Structural Clay Tile (C 112 - 35 T), as revised, and Definitions of Terms Relating to Structural Clay Tile (C 43 - 33 T) were unanimously approved for reference to letter ballot of the Society for adoption as standard.

On behalf of Committee C-4 on Clay Pipe the chair presented on the floor at the annual meeting a recommendation for the withdrawal of the Standard Definitions of Terms Relating to Sewer Pipe (C 8 - 24) since these have been superseded by the existing Tentative Definitions of Terms Relating to Clay Sewer Pipe (C 8 - 35 T). This recommendation was unanimously approved, subject to favorable letter ballot of Committee C-4.[3]

The report of Committee D-7 on Timber was presented by S. R. Church. The Tentative Specifications for Zinc Chloride were accepted for publication as tentative. The revisions proposed for immediate adoption in the Standard Specifications for Creosote (D 390 - 35) and for Creosote - Coal Tar Solution (D 391 - 35) were unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote.

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[1] This recommendation was submitted to letter ballot of Committee C-10 which consists of 30 members; 25 members returned their ballots, all of whom voted affirmatively.

[2] This recommendation was submitted to letter ballot of Committe C-10 which consists of 30 members; 25 members returned their ballots, of whom 24 voted affirmatively and 1 negatively.

[3] This recommendation was submitted to letter ballot of Committee C-4 which consists of 18 members, 13 members returned their ballots all of whom have voted affirmatively.

The proposed revision of the Standard Specifications for Structural Wood Joist and Planks, Beams and Stringers, and Posts and Timbers (D 245 - 33) in the form of separate Tentative Specifications for Structural Wood Joist and Plank, Beams and Stringers, and Posts and Timbers (D 245 - 36 T) were accepted for publication as tentative to replace the existing standard, the withdrawal of which was accordingly approved.

Mr. W. R. Fuller then assumed the chair.

The report of Committee D-17 on Naval Stores was presented by the chairman, F. P. Veitch.

The report of Committee D-1 on Preservative Coatings for Structural Materials was presented by the secretary, M. Rea Paul. The revisions proposed for immediate adoption in the Standard Methods of Routine Analysis of Yellow, Orange, Red and Brown Pigments Containing Iron and Manganese (D 50 - 33), of Yellow and Orange Pigments Containing Chromium Compounds, Blue Pigments and Chrome Green (D 126 - 35) and of Dry Cuprous Oxide (D 283 - 33) were unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote. The proposed revisions of the Standard Specifications for Lithopone (D 208 - 26) and Methods of Sampling and Testing Shellac (D 29 - 33) were accepted for publication as tentative.

The Tentative Specifications for High Zinc Sulfide Lithopone (D 385 - 34 T), as revised, for Zinc Sulfide (D 386 - 34 T), as revised, for Titanium Dioxide (D 384 - 34 T), for Amyl Acetate (from Fusel Oil) (85 to 88 per cent Grade) (D 318 - 34 T), for Industrial 90 per cent Benzene (Benzol) (D 361 - 33 T), for Industrial Pure Toluene (Toluol) (D 362 - 33 T), for Industrial Xylene (Xylol) or Solvent Naphtha (D 364 - 33), Specifications and Tests for Tricresyl Phosphate (D 363 - 33 T), Methods of Test for Tinting Strength of White Pigments or White Pigment Pastes (D 332 - 35 T), and for Mass Color and Tinting Strength of Dry Color Pigments or Pastes (D 387 - 35 T) were approved for reference to letter ballot of the Society for adoption as standard. The tentative revision of the Standard Methods of Routine Analysis of Yellow and Orange Pigments Containing Chromium Compounds, Blue Pigments and Chrome Green (D 126 - 35) was approved for reference to letter ballot of the Society for adoption as standard. The withdrawal of the tentative revision of the Standard Definitions of Terms Relating to Paint Specifications (D 16 - 24) was approved.

The following revisions of the Standard Methods of Sampling and Testing Turpentine (D 233 - 33) presented for immediate adoption on the floor at the annual meeting, were unanimously approved for reference to letter ballot of the Society for adoption as standard, subject to favorable letter ballot of Committee D-1:[1]

Section 2 (a).—Change the first sentence of the second paragraph of this section to read as follows by the addition of the italicized word and figure and the omission of those in brackets:

> The composite sample thus obtained shall be thoroughly mixed and from it three samples of not less than [1 qt.] *1 pt.* each shall be placed in clean, dry, glass bottles or tin cans, which shall be nearly filled with the sample and securely stoppered with new, clean corks or well-fitting covers or caps.

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[1] This recommendation was submitted to letter ballot of Committee D-1 which consists of 207 members; 93 members returned their ballots, of whom 73 have voted affirmatively, and none negatively.

Section 2 (*b*).—Change from its present form: namely,

> (*b*) *From Loaded Tank Car or Other Large Vessel.*—The composite sample taken shall be not less than 5 gal. and shall consist of numerous small samples of not more than 1 qt. each taken from the top, bottom, and intermediate points by means of a metal or glass container with removable stopper or top. This device, attached to a suitable pole, is lowered to the various desired depths, when the stopper or top is removed and the container allowed to fill. The sample thus obtained is handled as described in Paragraph (*a*).

to read as follows:

> (*b*) *From Loaded Tank Car or Other Large Vessel.*—The composite sample shall be a mixture of three 1-qt. samples, one taken from the top, one from the middle section, and one from the bottom[a] of the car or tank by means of a metal or glass container with removable stopper (see Section 46, Fig. 1 of the Standard Methods of Sampling Petroleum and Petroleum Products (A.S.T.M. Designation: D 270) of the American Society for Testing Materials), or by means of a sampling bomb or thief (see Section 55 (*d*), Fig. 5 of the Standard Methods D 270). The sample thus obtained shall be handled as described in Paragraph (*a*).

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[a] The "bottom" sample shall be taken above the separated water that may be in the bottom of the tank.

Section 6.—Change from its present form: namely,

> 6. Determine specific gravity at 15.5/15.5 C., by any convenient method that is accurate within 2 points in the fourth figure.

to read as follows:

> 6. Determine specific gravity at 15.5/15.5 C., by any convenient method that is accurate within 2 points in the fourth figure. Specific gravity determinations may be made at any convenient temperature other than 15.5 C. If done with a hydrometer or other apparatus standardized at 15.5 C., the value thus obtained may be corrected to 15.5/15.5 C. by adding to or subtracting from the observed reading 0.00082 for each degree Centigrade that the temperature of the liquid is respectively above or below 15.5 C. If specific gravity is determined on any basis other than by reference to 15.5 C., the specific gravity at 15.5/15.5 C. shall be calculated by first calculating the density at the temperature of observation, then converting this to density at 15.5 C. by applying the above factor, and finally obtaining the specific gravity by dividing the calculated density by 0.999 (density of water at 15.5 C.).

A report by Subcommittee VII on Accelerated Tests for Protective Coatings, presented on the floor at the annual meeting, which had been accepted by the committee for inclusion in its annual report but had not been preprinted, was accepted subject to approval by Committee E-6 on Papers and Publications.

A paper entitled "The Testing of Organic Finishes," by A. E. Schuh, was presented by the author and discussed. The paper was illustrated with motion pictures.

A paper entitled "Methods of Determining Gloss," by Richard S. Hunter, was presented from manuscript by the author and discussed.

There being no further business the chairman then declared the Thirty-ninth Annual Meeting adjourned *sine die.*

THE TESTING OF NON-MATERIALS

ANNUAL ADDRESS BY THE PRESIDENT

HERVEY S. VASSAR

JUNE 30, 1936

Wireless to The New York Times:

> "LONDON, March 11.—King Edward VIII, after visiting the great new liner Queen Mary and the squalid Glasgow slums last week, turned to someone near him and asked: 'How do you reconcile a world that has produced this mighty ship with the slums we have just visited?'
>
> This was recounted by Lord Melchett at tonight's annual dinner of the Institute of Metals, who said 'That is the problem we have to solve, and it is useless to go out and solve scientific problems if we cannot solve that.' "

The foregoing clipping from *The New York Times* has suggested the line of thought that I wish to present to you this morning.

During the five days of this Thirty-ninth Annual Meeting of the Society, eighteen formal sessions and some one hundred and seventy-five committee meetings will be held. All of these meetings will be given over exclusively to the consideration of materials. This is as it should be in furthering the Society's reasons for existence, but it does appear to justify spending a few minutes in the consideration of our approach to the numerous problems which have to do with satisfactory living and which so vitally concern each one of us.

Under our form of government every citizen who lives a normal life is in his daily associations compelled to form and express opinions and constantly to make many decisions dealing with home and family and business, under that particular code for living together which we know as "the law." Under such conditions he becomes perforce something of a sociologist and something of an economist. For we all must live together regardless of race, class, or creed.

For the several reasons I have given, no apology would seem to be necessary for the subject chosen for a brief discussion today.

Some years ago the writer of a book dealing with human relations called attention to the discrepancy in the comparative rates of advance of the physical and social sciences—suggesting that the former progress geometrically and the latter arithmetically. In his opinion many of the ills of society were attributable to this disparity in rates of progress.

As a starting point it may be well for us to consider some of the reasons for the continued success of the American Society for Testing Materials in its work in the physical field. These matters have frequently been emphasized in reviews of the Society's work. In this discussion of the testing of non-materials, in which I would include all those questions, social and economic, involved in the art of living together, may I again, and quite briefly, summarize a few of the attributes which have characterized this Society.

First among these stands a definite purpose well stated by the founders of the Society in its charter. The words are familiar to all from their constant reiteration; "the promotion of knowledge of the materials of engineering and the standardization of specifications and methods of testing." I will simply call attention here to the fact that in the wording used, "knowledge" precedes "standardization." This order of precedence, in my opinion, is not mere happen-so.

Next, the Society definitely adopted, and from year to year has strengthened, clear-cut methods of procedure in its work, methods based on free discussion and conference. All parties at interest are represented and wherever possible disinterested specialists, referred to in the Society as "general interests," are included as participants. Before final action is taken by the Society on any particular matter, there must be reasonable assurance that the recommendation rests on a factual basis; that it is generally acceptable to the parties directly affected; and that its adoption promises to be in the best interests of industry.

The inevitability of change has been fully recognized in setting up the machinery of the Society, and adequate provision has been made for the growth of standards to meet the changing needs of industry as brought about by scientific advance and development of manufacturing processes.

Stability, without which the standards of the Society would never have attained their present position of preeminence in the engineering world, has been attained by a procedure safeguarding standards against hasty or ill-considered revisions. At times this policy is irksome to the more impetuous, but its wisdom has been proved by the test of experience. It is the evolutionary not the revolutionary way.

The willing acceptance of individual responsibility by our members in energetically furthering the work of the Society has been outstanding among the reasons for the organization's progress.

Last, but by no means least, the Society has had high ideals of service to industry.

In turning now to the testing of non-materials let us first attempt a sort of airplane view of the people of this republic as seen through the eyes of a garden-variety engineer. There are, according to the 1935 estimate of the census, some 127 millions of us. At the start the futility must be recognized of any attempt at a definite classification into groups as regards our individual interest in, or approach to, the maze of social problems which confronts us. To place each individual in a suitable category introduces difficulties far greater than sometimes face our own organization in such matters as, for example, ferrous *versus* non-ferrous metals. When the resistance of inanimate things to classification is so apparent, what can we expect from personalities?

The range covered by such a classification would extend from the few entirely self-centered individuals, devoid of a sense of social responsibility, and without awareness of the problems of the day, down through numerous groups, including that irresponsible element ever ready to accept any political or social nostrum, and ultimately, at the end of the scale, Edwin Markham's "man with the hoe."

The comforting thought to me always is that the great mass of the American people is to be found in between these extremes, and is made up of "just folks" who are reasonable, willing to work, who respond to fair conditions, and who are, on the whole, rather long suffering. No country on earth is blessed with a better citizenry than ours, and I am optimistic enough to trust the people's ultimate judgment on the intricate questions involved in their common enterprise of living together. The turbulence which accompanies it, is a part of the price we must pay for popular government. Some one has said that a monarchy may be compared to a boat riding the waves until it strikes a rock and goes down, while a democracy is like a raft, usually remaining afloat, though the voyagers feet are always in the water.

Innumerable influences are continually at work on each of us in shaping our attitudes toward social questions. The power of tradition, and social and business environment, to give our minds a permanent set "for" or "against" any particular course of action, regardless of its merits, needs no comment. In the field of physical science our individual usefulness is usually directly proportional to our ability to control these preconceived opinions, which are so often mere prejudices with little, if any, foundation in reason or in fact. Is it any less necessary to approach the testing of non-materials with a fairly open mind?

Let us turn now to a few of the prevailing popular attitudes toward specific social questions to see what methods we as a people appear to employ in the testing of non-materials.

Take unemployment. A few days ago there appeared in a business paper a cartoon which caught my eye. It represented Uncle Sam addressing the perspiring business man and requesting employment for three rather dubious looking individuals labeled Mr. Won't Work, Mr. Can't Work, Mr. Never Did Work. Above in large letters appeared the question "Who are the unemployed after you take out these?" How many supposedly intelligent people during the past several years have been repeating the implication of that cartoon? Constant repetition has brought to them the comforting conviction that there is no deep-seated unemployment problem which will not be immediately solved by a burst of business prosperity.

A year or so ago announcement was made of the invention of the long-awaited mechanical cotton picker. More recently a brief note in the papers called attention to the quandary of the inventors, now said to be seriously disturbed by the social responsibility involved in the introduction of the machine, due to its effect on an already complicated labor situation in certain parishes and counties of the cotton raising states. Is the reported dilemma of the Rust brothers only a sentimental fancy?

How far do we apply A.S.T.M. principles in our attitude toward this vital social problem? What methods of test do we employ?

Turn to the question of labor. The man on the street will usually be found aligned definitely, and perhaps explosively, "pro" or "con" at the mere mention of a labor difficulty possibly a thousand miles away. Occasionally, and happily with increasing frequency of late, industrial organizations are found in which there never seems to be serious labor controversy. Their constant goal has been, not the winning of a war, but a better understanding between management and men. Such organizations have almost invariably prospered.

Looking below the surface in these cases, there will usually be found an enlightened management that, freeing itself of ready made opinions and prejudices, has definitely applied to labor problems some of the rational principles that have been fruitful in the carrying on of A.S.T.M. work.

Attempts at the introduction of efficiency methods are frequently, and not unnaturally, opposed by labor, largely because they are not understood by labor. This Society should be proud of the recent award to the president of one of our member companies, by the American Management Association, of the Henry Lawrence Gantt gold medal. Mr. Morris E. Leeds, President of The Leeds & Northrup Co. has just received this honor for emphasizing the importance of preparing "a suitable background in the attitude of all ranks of an organization toward methods of increasing efficiency."

Much is being said about security—social security as represented by old age and unemployment insurance; financial security as represented by the guaranteeing of bank deposits and loans. Every group, regardless of its place in the business or social scale, apparently wants some form of security and wants Uncle Sam to attend to it. The vision of an economic Santa Claus seems to have permeated all groups of society.

With what kind of testing equipment do we approach these questions?

In the matter of the fomenting of racial, national, and class hatreds—at present one of our highly popular forms of stirring up trouble—as if we did not already have enough—where do we as technologists stand? Are we following the popular pattern of behavior by joining in the various crusades of discord and hatred, or are we striving against our traditional and acquired prejudices, toward a just evaluation of individuals and groups?

The world today worships force as an instrument for the settlement of all human differences. This is evident not only in the international armament race but in the attempts by groups in every field of human activity to curb by force, possibly in the form of legal enactment, the liberties of other groups who may in some way disagree with them. Our common expression "there ought to be a law" voices this sentiment. The advocates of force in its various forms, as a convenient expedient to serve immediate ends, seem to forget that every unwarranted use of force is a direct blow at the foundation of their own liberties.

As members of A.S.T.M. we would laugh at the suggestion that in attacking a new and controversial subject in one of our standing committees we at once plunge into a battle of words on the most disputed points, without first having established a common ground made up of those things upon which we have found ourselves already in fair agreement. Yet is it not too frequently considered quite proper to initiate the consideration of a social question with a battle of words?

Only a few weeks before Fort Sumter was fired on, President Lincoln in his inaugural address discussing impending secession said:

> "Suppose you go to war, you cannot fight always; and when after much loss on both sides, and no gain on either, you cease fighting, the identical old questions as to terms of intercourse are again upon you."

We have in this country several hundred associations of specialists in science and technology, with an aggregate membership of hundreds of thousands. In the treatment of the physical problems in their respective fields, a reasonably successful technique has been developed. If you like you may call this "the scientific approach" but perhaps "common sense" would be just as good a name. Unless we are willing to admit the truth of the charge that we have degenerated into a nation of cynical materialists, devoid of those characteristics of our forefathers of which we boast, is there any valid reason for abandoning our methods of approach when stepping, as we must, from our vocation into the non-materials field?

It has been said that a few thousand people are sufficient at any time to change the thinking of America. If this is true, there is within the organized workers in the field of physical science a potential force fully capable of being the leaven in the meal of society, which can aid mightily in the development of a more rational approach to the problems of the day.

On this coming celebration of Independence Day we again will be asked to remember those men of 1776 who sacrificed their comfort, their possessions, and in many cases, their lives in the common interest. The challenge that comes to Americans in 1936 is less spectacular. It may not be a call to physical combat but it does demand honest, intelligent, and unselfish thinking as each one does his part in bringing adequate standards to the testing of non-materials.

ANNUAL REPORT OF THE EXECUTIVE COMMITTEE

The Executive Committee offers the following report on general Society activities for the year ending with this annual meeting:

Membership:

The membership of the Society on June 1, 1936, was 3741. Statistics showing gains and losses in the various classes of membership are as follows:

Class of Membership	Membership		Losses				Additions		Total		
	June 1, 1935	June 1, 1936	Resignations	Dropped	Death	Transfer	Transfer	Election	Loss	Gain	Increase
Honorary	2	1	...	..	1	..	..	...	1	...	1[a]
Life or Perpetuity	11	10	...	..	1	..	..	...	1	...	1[a]
Sustaining	8	10	...	..	..	..	2	...	...	2	2
Company, Firm, etc.	870	911	20	7	..	7	10	65	34	75	41
Individual, etc.	2680	2766	85	65	20	10	19	247	180	266	86
Junior	41	43	1	5	..	14	..	22	20	22	2
Total	3612	3741	106	77	22	31	31	334	236	365	129
Student	148	204	16	76	..	11	..	159	103	159	56

[a] Decrease.

The upward climb in membership, which was begun over a year ago, has continued at an accelerated pace. The net gain for the year of 129 compares with the net gain a year ago of 43 and with net losses for the years ending June 1, 1934, and 1933, of 164 and 430 respectively. Resignations throughout the year were somewhat less and delinquencies considerably less than for the preceding year; losses from all sources this year (excluding transfers) were 205 compared to 276 a year ago and 418 two years ago. Elections to membership have continued to increase, the figure for this year being 334 compared to 319 and 254 for the past two years. It is gratifying to note that approximately one-fifth of the elections represent renewals or reinstatement of former members or replacement of memberships resigned. The number of student members increased during the year from 148 to 204, a net gain of 56.

Two new sustaining memberships were acquired during the year, namely, the Inland Steel Co. and the National Smelting Co., bringing the total of such sustaining memberships to ten.

The improved membership position is gratifying and is due in no small measure to the very real interest that many members are taking in the effort to regain the ground lost during the depression years. The assistance of these members and of such groups as the Special Membership Committee and the several District Committees is appreciated. The help of all will be needed in the years ahead as our efforts are continued to reach our former membership level, which is greatly needed as a basis for expansion of technical activities that is becoming increasingly important.

The Society has lost the following members through death:

	DATE OF MEMBERSHIP		DATE OF MEMBERSHIP
Angstadt, H. F.	1928	Madison, John O.	1934
Becker, Sidney K.	1925	McKee, James	1930
Carpenter, Louis G.	1902	McNiff, Gilbert P.	1916
Goss, William G.	1933	Merrill, Meldon H.	1935
Hooker, A. H.	1906	Phillips, Asa E.	1915
Hulse, Edward Pierce	1936	Plaskett, Clyde A.	1921
Ickes, Elwood T.	1906	Pool, Arthur J.	1935
Johnson, B. H.	1931	Shore, Albert F.	1910
Larsson, C. G. Emil	1903	Strobel, Charles L.	1898
Lenth, George C. D.	1920	Tretch, William J.	1906
Lesley, Robert W.	1898	Zeidler, John L.	1915

Among these members are many who have contributed much to all that the Society stands for. Robert W. Lesley was one of the founder members of the Society, Vice-President for the years 1902 to 1912, and was elected an honorary member in 1927. George C. D. Lenth had served on the Executive Committee 1931–1933, was secretary of Committee C-4 on Clay Pipe since 1933, and at the time of his death was secretary of the Chicago District Committee; Asa E. Phillips had been chairman of Committee C-13 on Concrete Pipe since 1931; and C. A. Plaskett had been secretary of Committee D-10 on Shipping Containers since 1924. E. T. Ickes, C. G. E. Larsson and J. L. Zeidler served for many years on committees of the Society.

Committee Activities:

As revealed by the program of the present annual meeting, the Society is completing a year of fruitful committee work with respect both to investigations into the properties of materials and the standardization of specifications and methods of test. As usual, the annual reports of two administrative committees, E-9 on Research and E-10 on Standards, supplemented by reviews that will appear in the July and October issues of the *Bulletin*, give a general summary of these activities. This report, therefore, will deal briefly with various administrative matters concerning the standing committees.

The discontinuance of Committee C-2 on Reinforced Concrete was reported last year. The Tentative Rules for Inspection of Concrete and Reinforced Concrete (C 44 – 22 T) written by that committee have, upon recommendation of the Joint Committee on Concrete and Reinforced Concrete, been withdrawn and the American Concrete Institute has been requested to assume sponsorship for this subject.

Committee C-12 on Mortars for Unit Masonry is in course of reorganization. Having been unable to make any substantial progress in its work, due in part to conditions growing out of the depressed state of the construction industry, the committee collectively resigned for the purpose of clearing the way for reorganization on a somewhat modified basis, with the scope possibly restricted to the more urgent research and standardization needs of the industry. As yet, no steps towards actual reorganization have been taken.

Committee D-16 on Slate, which has been inactive for several years, has been discontinued as a separate committee and its functions merged with those of Committee C-18 on Natural Building Stones under the revised title "Natural Building Stones and Slate," except that sponsorship for standards dealing with the electrical properties and uses of slate has been assigned to Committee D-9 on Electrical Insulating Materials. Members of Committee D-16 have been given the opportunity of serving on the other committees.

Another administrative change of a somewhat similar nature has just been completed in the merger of Committees A-8 on Magnetic Analysis and A-6 on Magnetic Properties, under the present title and designation of the latter committee, which has extended its scope to include the functions of the first-named committee. For many years Committee A-8 has stimulated research in magnetic analysis of metals and the correlation of magnetic and physical properties, and has been responsible for a number of reports and technical papers published in the *Proceedings* of the Society. In recent years, there has been relatively less interest in this subject and little for Committee A-8 to do. The consolidation of the two committees, which have always had considerable overlapping of membership, simplifies the committee set-up and still retains the means for studies of magnetic analysis as opportunity offers.

It has been decided, with the substantially unanimous approval of the members of the committee, to discontinue Committee A-4 on Heat Treatment of Iron and Steel. This has come about in part through the arrangements, mentioned later in this report, for cooperation with the American Society for Metals in the development of recommended practices for heat treatment of metals, and in part through the fact that in recent years the various metals committees of the Society have found it expedient themselves to develop such requirements for heat treatment as were needed for references in standards. The committee has been inactive for the past several years and while it served an extremely useful and necessary purpose in the earlier days of the Society, it has in a measure outlived its opportunities for useful service under the present circumstances. In line with this action, the three recommended practices for heat treatment—Annealing of Miscellaneous Rolled and Forged Carbon-Steel Objects (A 35 – 24), Heat Treatment of Carbon-Steel Castings (A 36 – 24) and Carburizing and Heat Treatment of Carburized Objects (A 37 – 27)—will be withdrawn. The Standard Definitions of Terms Relating to Heat Treatment Operations, Especially as Related to Ferrous Alloys (A 119 – 33), written by a joint committee of the Society of Automotive Engineers, American Society for Metals and A.S.T.M., will be transferred to the jurisdiction of Committee E-8 on Nomenclature and Definitions.

Two new standing committees were organized at the 1935 annual meeting, namely, D-3 on Gaseous Fuels, under the chairmanship of A. C. Fieldner, and E-3 on Methods of Chemical Analysis of Metals, under the chairmanship of G. E. F. Lundell. With the organization of the latter committee, the subcommittees of the individual metals committees on methods of chemical analysis have been discontinued, each such committee being formally represented upon Committee E-3.

A new standing committee on Soaps and Other Detergents will be organized during this annual meeting, under the temporary chairmanship of H. P. Trevethick. A thorough canvass among producers and users of these products has indicated that the Society can render a valuable service in the standardization of methods and specifications in this field. Many competent experts have accepted invitations to serve on the committee, which for the present is expected to confine its work to soaps in general, soap powders and cleansers, possibly broadening later to include some of the raw materials that go into these products.

During the year the Executive Committee authorized the appointment of two other standing committees. The first, a Committee on Paper, has been under consideration for several years. An organization committee under the chairmanship of Roger C. Griffin has made considerable progress in determining the most useful fields of activity for the committee, which appear to be in the development of definitions, nomenclature and general methods of testing paper, interpretation of test data in terms of applicability to use requirements, and development of specifications for certain paper products, of which multi-wall paper bags and paper and fiber boards for shipping containers are important examples. The second new committee, on Soils for Engineering Purposes, will meet a growing need for study of soils as engineering materials, including the development of standard methods of test. It will extend into a broader field the work of the past two years in Committee D-4 on Road and Paving Materials in the development of tests for soils for highway construction. C. A. Hogentogler is temporary chairman. It is expected to organize each of these new committees this fall.

The Executive Committee has extended and defined more precisely the functions of Committee E-10 on Standards in relation to the activities of joint committees and of sectional committees functioning under A.S.A. procedure, as follows:

1. To assist in the selection of personnel of sectional committees organized with the A.S.T.M. as sponsor.

2. To take action with respect to invitations to appoint A.S.T.M. representatives on joint committees and on sectional committees functioning under other than A.S.T.M. sponsorship, including recommendations to the President of individuals who should be designated as A.S.T.M. representatives.

3. To receive and review reports from Society representatives on joint committees and sectional committees.

4. To receive and act upon reports of sectional committees under A.S.T.M. sponsorship containing recommendations with respect to submission of standards to A.S.A.

5. To take action on the submission of A.S.T.M. standards to the A.S.A. under the proprietary method of sponsorship.

The activities of the standing committees have expanded considerably in recent years and this expansion has indicated the desirability of more carefully defining the scope of the committees. The Secretary-Treasurer has accordingly been directed to ask all committees to prepare statements of scope for review by the Executive Committee. In the meantime the Regulations Governing Standing Committees have been modified to provide that all new committees shall prepare statements of scope when organized.

Standard Samples.—The Executive Committee has been considering the interest of the Society in the preparation and maintenance of standard samples of materials for use in checking methods of analysis and test,—a work that the National Bureau of Standards has been doing for many years. It has been noted that there are a number of materials for which the Society has written standard methods of analysis that are not represented in the Bureau's list of standard samples, usually because of technical difficulties or lack of necessary funds. The Bureau has given its cordial assurance that it would welcome the help of the Society in the establishment of standard samples where there are none at present, and there may be other ways in which A.S.T.M. could consistently cooperate with the Bureau in this work. As a step in the study of this problem, the standing committees are being asked, first, whether the standard samples that have so far been prepared by the Bureau are adequate and satisfactory with respect to the materials in which the committees are interested; second, whether there are any materials of interest to the committees for which standard samples have not been prepared by the Bureau; and third, if so, whether the committees will be prepared to lend their support and that of their members in aiding the Bureau to establish such standards.

Modifications of Regulations Governing Standing Committees:

The following modifications of the Regulations Governing Standing Committees[1] have been approved by the Executive Committee and Committee E-5 on Standing Committees (the latter being jointly responsible with the Executive Committee), and will become effective at this annual meeting:

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[1] 1935 A.S.T.M. *Year Book*, p. 237.

Section 4. Permanent Organization.—Add the following sentence at the end of this section:

> The committee shall prepare a statement of its scope, which shall be subject to the approval of the Executive Committee.

Section 5. Supplementary Regulations Governing Standing Committees.—Add the words "Statement of scope" after the words "such regulations to cover the following."

Section 8. Election of Officers.—Change the third sentence to read as follows by the addition of the italicized words:

> The term of office of every officer shall be two years, *expiring at the close of the annual meeting*, and officers shall be eligible for re-election.

Section 13. Matters of Engineering Design.—Change to read as follows by the deletion of the words in brackets and the insertion of the italicized words:

> In the preparation of proposed standards the consideration of matters of engineering design or construction shall not in general be regarded as falling within the province of the Society. If, however, it should appear to a given committee that [the consideration of] *reference to* such matters is [, for special reasons,] indispensable in [specifications] *standards* designed to cover the customary relations between the producers and consumers of a given product, [then reference to such matters] *the committee, before embodying such reference* in proposed [specifications] *standards* [for that product] shall [be permitted] *request approval of the Executive Committee for such references* within the scope necessary for the particular purpose above stated. *The Executive Committee shall give such approval only when the indispensability of such procedure has been demonstrated.* Proposed standards embodying features of the character in question shall be submitted by the committee concerned to the Executive Committee for consideration and comment not later than the quarterly meeting immediately preceding the annual meeting at which the proposed standards are to be presented.

Section 17. Reports at Annual Meetings.—Add the following new paragraph after the third paragraph:

> In the year in which the Book of Standards is issued, standing committees shall report, either to the Society or to the Executive Committee, whether all standards within their respective jurisdictions that have stood for six years or more without revision are still considered to be in accord with present practice and requiring no revision.

The purposes of the modifications of Sections 4 and 5 dealing with statements of scope of committees, of Section 8 defining terms of office of committee officers and of Section 17 requiring periodic reviews of standards, are essentially self-evident.

The modification of Section 13 has developed from discussions with the American Concrete Institute regarding the scopes of activities of the two societies, mentioned later in this report, which involved consideration of the relationship of A.S.T.M. to matters of engineering design and construction as applied to the field of concrete. Such matters, of course, are not regarded generally as falling within the province of the Society. Upon occasion, however, it has appeared to certain committees of the Society that some reference to such matters is indispensable in the writing of A.S.T.M. standards. Heretofore the committees have been permitted to include reference to such matters in proposed standards if they felt them to be indispensable, but were required to submit such proposed standards to the Executive Committee for consideration and comment before their submission to the Society. Under this procedure it is possible for a committee on its own initiative to proceed to deal with matters of engineering design or construction that may later not be approved by the Executive Committee and may in the meantime have led the Society to go outside of its proper field. The Executive Committee has concluded that it will be better in such cases for each standing committee, before embodying references to matters of engineering design or construction in proposed standards, to seek approval of the Executive Committee for such references within the scope necessary for a particular purpose and in so doing to demonstrate the indispensability of such references. In this way the Executive Committee will have opportunity to review a given case before a standing committee embarks upon a project that will deal in some way with design or construction and can pass upon the case on its merits before the standing committee undertakes actual development of the project. In the event that approval is given and the committee prepares the proposed standard, it is still considered desirable that the standard itself shall be further reviewed by the Executive Committee before it is submitted to the Society.

While this modification has come about through conferences with the American Concrete Institute, as explained, it has nevertheless been studied in the light of our relationship with other technical societies that deal with matters of engineering design and construction and with which the Society has established various channels of cooperation.

District Committees:

The reorganization of the eight district committees of the Society under the Charter for District Committees referred to in the report a year ago has been completed. The committees have functioned actively along various lines during the year; reports of their activities have been given in various issues of the A.S.T.M. *Bulletin* and need not be detailed here; in fact a section of the *Bulletin* is being devoted to accounts of the district committees and meetings held under their sponsorship. Such meetings held during the past year are mentioned in the following section of the report. The district committees in the order of their formation are: Chicago, Detroit, Southern California, Northern California, Pittsburgh, Cleveland, New York and Philadelphia.

Meetings and Local Activities:

Since the Thirty-eighth Annual Meeting last June in Detroit, the Seventh Regional Meeting was held in Pittsburgh, March 4, 1936, under the auspices of the Pittsburgh District Committee. The technical feature of the meeting was a Symposium on High-Strength Constructional Metals developed by the Pittsburgh committee through a special committee headed by Jerome Strauss. About 225 members and visitors attended the two sessions at which the five papers comprising the symposium were presented. The papers and discussions are being edited for publication. The March, 1936, *Bulletin* gives an account of the various activities associated with the Regional Meeting.

The Spring Group Meetings of Committees were held at Pittsburgh, March 2 to 6, inclusive. About 140 meetings of main committees, subcommittees and sections were held, and the total registered attendance, 626, surpassed all previous records for these meetings. Much constructive work was accomplished by our committees during this week of intensive work.

An outstanding feature of the Society year has been the number of successful local meetings that have been held under the auspices of the district committees. Accounts of these meetings have appeared currently in the Society *Bulletin*, but it is desired to record the meetings here with an expression of appreciation from the Executive Committee for this form of activity, which is helpful in many ways in advancing the interests of the Society. The first of such meetings was held in Philadelphia on January 21, 1936, under the joint auspices of the Philadelphia District Committee and the Engineers' Club of Philadelphia; the technical feature was a Symposium on Fuels presented in two sessions, which was so well received that it has since been published. The second meeting was on January 27 in Cleveland, at which was featured a Symposium on Pearlitic Malleable Cast Iron sponsored by the Cleveland District Committee. This symposium has likewise been published.

On March 10 the Southern California District Committee held at Los Angeles the first meeting of local members and guests since the district committee was reorganized. Beginning with a talk by P. E. Jeffers on "Progress in Earthquake Resistant Design and Construction," the meeting then became an open forum for discussion of various topics relating to A.S.T.M. standards. Out of this discussion there developed four recommendations which the district committee submitted to the Executive Committee and which have been placed in the hands of the appropriate standing committees for study. On March 12 the members of the Chicago district joined with the Chicago Chapter of the American Society for Metals in a dinner meeting featuring an address by A. V. de Forest on "Unusual Methods of Inspection."

On April 7 the Detroit District Committee arranged a local meeting at which Dr. John Johnston, Director of Research of the U. S. Steel Corporation, was the guest speaker on the subject "The Use and Abuse of Tests." On April 8 the Chicago District Committee sponsored a local meeting which was addressed by Prof. D. B. Keyes, University of Illinois, on the subject "Value to the Industries of the Exact Determination of Physical and Chemical Properties." Finally, in New York on April 21 Mr. Carlton Ellis addressed a well-attended meeting of Society members and guests held under the auspices of the New York District Committee. His subject was "Synthetic Resins."

The President attended all of these local meetings save that held in Los Angeles and at each one brought appropriate greetings from the Society to the members and guests present.

Publications:

The past year has been a busy and active one with respect to Society publications. The following regular publications were issued and distributed to the members: *Proceedings*, including preprints of reports and papers; the 1935 Supplement to the Book of A.S.T.M. Standards; the Index to A.S.T.M. Standards and Tentative Standards; and the Year Book. Six issues of the A.S.T.M. *Bulletin* were published. The Book of A.S.T.M. Tentative Standards and the Symposium on Paint and Paint Materials, containing the papers and discussions at the Philadelphia Regional Meeting in March, 1935, were published and furnished to members on order. A comparative statement of the volume of the regular publications for the past four years follows:

	1932, PAGES	1933, PAGES	1934, PAGES	1935, PAGES
Proceedings	1895	1914	2288	2279
Book of A.S.T.M. Standards	....	2348	....	....
Supplement to Book of A.S.T.M. Standards	102	....	224	216
Index to A.S.T.M. Standards and Tentative Standards	119	124	142	160
Year Book	....	248	251	256
Supplement to Year Book	133	....	....	....
Book of A.S.T.M. Tentative Standards	1236	1164	1288	1628
Regional Meeting Symposium	159	121	119	156
Report on Significance of Tests of Concrete and Concrete Aggregates	....	....	127	....
	3644	5919	4439	4695

During the past year the Society published the following Compilations of Standards:

A.S.T.M. Standards on Preservative Coatings for Structural Materials (Committee D-1), 395 pages, 1600 copies, published biennially.

A.S.T.M. Standards on Petroleum Products and Lubricants (Committee D-2), 366 pages, 4000 copies, published annually.

A.S.T.M. Standards on Electrical Insulating Materials (Committee D-9), 316 pages, 700 copies, published annually.

A.S.T.M. Standards on Rubber Products (Committee D-11), 208 pages, 1000 copies. This is a new publication and is being published tentatively on a biennial basis.

A.S.T.M. Standards on Textile Materials (Committee D-13), 254 pages, 1200 copies; basis of publication changed from biennial to annual.

The two other compilations of standards the Society has published, which complete this series, are those dealing with Refractory Materials (Committee C-8) and with Coal and Coke (Committee D-5), each of which were published following the 1934 annual meeting and are expected to be published in revised form this fall on a biennial basis. A one-page supplement to the standards on coal and coke was printed during the year.

Other reprints and special publications printed last year include the following:

Symposium on Motor Lubricants (1933), second printing, 121 pages, 500 copies.

Symposium on Cast Iron (1933), second printing, 170 pages, 1000 copies.

Symposium on Industrial Fuels, 76 pages, 2000 copies.

Symposium on Pearlitic Malleable Cast Iron, 36 pages, 1000 copies.

Symposium on the Place of Materials in Automobile Roads and Rides, 33 pages, 500 copies.

"Role of Materials in Modern Housing," by J. E. Burchard, 30 pages, 500 copies.

Supplement to 1933 A.S.T.M. Manual on Presentation of Data (Committee E-1), 27 pages, 1500 copies.

Symposium on Spectrographic Analysis, 51 pages, 1000 copies.

Marburg Lecture "Aircraft: Materials and Testing," by L. B. Tuckerman, 44 pages, 600 copies.

Report of Committee A-5 on Corrosion of Iron and Steel, 31 pages, 3 insert plates, 1000 copies.

Report of Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys, 35 pages, 600 copies.

Report of Committee B-6 on Die-Cast Metals and Alloys, 46 pages, 1000 copies.

Report of Committee D-14 on Screen Wire Cloth, 20 pages, 500 copies.

The Society *Bulletin* is being expanded as finances permit, in accordance with a previously announced policy. The *Bulletins* last July and October carried, respectively, the 1935 annual meeting addresses of Dr. C. F. Hirshfeld on "Relationship of Specifications to the Engineering Profession" and Miles L. Colean on "The Federal Housing Problem." In the December, 1935, issue two papers were published, one by M. Levinsohn and R. L. Dowdell on "Toughness of Tool Steels by the Charpy Impact Test" and another by J. C. Sprague on "Field Tests for Specific Gravity, Unit Weight and Voids of Concrete Aggregates." Still greater use of the Society *Bulletin* for papers of this character is planned for the coming year. The possibility of still further expansion into a technical journal to include technical papers and reports is under consideration.

A year ago the Executive Committee referred in its report to a study of the methods of publishing the standards of the Society being made by the Committee on Papers and Publications at the request of the Executive Committee. A report on these studies has been made and is under consideration. It is clear that no substantial change need be made this year in the publication of the two volumes of the Book of Standards, and the Executive Committee plans to discuss during the year with the standing committees some proposals that have been made for further division of the Book of Standards if and as needed. At the same time consideration is being given to the suggestion that the standards of the Society be published in "loose unit" form.

Finances:

Report for the Fiscal Year 1935.—The annual statement of the finances of the Society follows in the report of the auditors for the fiscal year January 1, to December 31, 1935.

Total receipts from dues and entrance fees in 1935 were $69,855.80, an increase of approximately $2400 over corresponding receipts for 1934, which in turn were $2000 above the "low" of 1933. These figures, of course, reflect the climb back towards the higher membership level of other years that has now begun. Receipts from sales of publications totaled $38,081.42; included in this total are receipts from sales of special reprints and miscellaneous publications amounting to $16,092.85, which is the largest income from this source in the Society's history. Receipts from sales of the special compilations of standards are included in this figure, together with sales of various technical symposiums and other reprints, all of which gives emphasis to the continued industrial demand for publications of this character. Sales of separate standards and of the bound publications of standards and tentative standards were likewise gratifying. Miscellaneous receipts include gross receipts from the 1935 Exhibit and from advertising in the *Bulletin* and Index to Standards and Tentative Standards. Total operating receipts (budgeted) were $120,357.09. Total operating disbursements with all current bills paid were $114,993.75, showing a favorable balance of $5363.34. Of this amount $5000 was placed in the reserve for publication of the 1936 Book of Standards, leaving a net balance of $363.34 on the year's operations.

The report of the auditors gives the balance sheet of assets and liabilities, including special and designated funds (that is, the Research Fund, Medal and Lecture Fund, and Committee Funds); statement of receipts and disbursements, in which items are classified into "operating" (budget) and "non-operating"; details of special funds; investment of Society and

REPORT OF THE AUDITORS FOR THE FISCAL YEAR, JANUARY 1, 1935, TO DECEMBER 31, 1935

PHILADELPHIA, January 10, 1936

MR. C. L. WARWICK, *Secretary-Treasurer*
AMERICAN SOCIETY FOR TESTING MATERIALS
Philadelphia, Pa.

Dear Sir:

We have examined the books and accounts of your Society for the year ended December 31, 1935. The books and accounts examined were found correct and in satisfactory condition.

We have prepared the annexed Balance Sheet as of December 31, 1935, and Statement of Cash Receipts and Disbursements for the twelve months ended that date, together with other supporting schedules. The schedules are in agreement with the records of your Society.

Investments owned were verified by actual inspection and count and found to be intact and in agreement with the schedule of securities owned as detailed herewith. We verified the collection of interest on investments owned for the year 1935 and found it fully accounted for, except interest on $6000 Missouri Pacific Railroad First and Refunding Mortgage 5's 1977 which defaulted in their interest payments September 1, 1933.

Respectfully submitted,
(Signed) JOHN HEINS AND CO.

BALANCE SHEET AS OF DECEMBER 31, 1935

(Including Special and Designated Funds)

ASSETS

General Funds:				
Current: Cash	$21 894.73			
Less checks drawn as of December 31, 1935—Cost of *Proceedings* in hands of Secretary-Treasurer that date	11 380.00			
		$10 514.73		
Investments (Market Value, $33,056.57)—Cost		36 180.42		
Accounts Receivable		7 531.42		
Total Current Assets—General Fund			$54 226.57	
Furniture and Fixtures			7 489.70	
A.S.T.M.-A.S.M.E. Symposium on Effect of Temperature: Special Account for Financing Book			1 668.41	
Claim Against Closed Bank			20.56	
Total General Funds				$63 405.24
Special and Designated Funds:				
Cash: A.S.T.M. Research Fund		$1 359.10		
Dudley Medal and Marburg Lecture Fund		619.42		
Committee Funds		10 716.81		
			$12 695.33	
Investments:				
A.S.T.M. Research Fund (Market Value, $6,183.13)—Cost		$7 363.41		
Dudley Medal and Marburg Lecture Fund (Market Value, $4,908.75)—Cost		6 625.00		
Committee Funds (Market Value, $6,051.55)—Cost		$6 000.00		
			19 988.41	
Total Special and Designated Funds				32 683.74
Total Assets				**$96 088.98**

LIABILITIES

General Funds:			
Current: Accounts Payable—			
Committee A-1	$35.00		
Committee C-1	484.46		
International Association for Testing Materials	26.85		
Advance Collections	2 149.29		
Total Current Liabilities—General Fund		$2 695.60	
Life Membership Fund	$3 005.20		
Headquarters Fund	1 041.56		
Publication Fund	3 015.00		
Book of Standards Reserve	10 023.44		
Surplus	43 624.44		
		60 709.64	
Total General Funds			$63 405.24
Special and Designated Funds:			
A.S.T.M. Research Fund		$8 722.51	
Dudley Medal and Marburg Lecture Fund		7 244.42	
Committee Funds		16 716.81	
Total Special and Designated Funds			32 683.74
Total Liabilities and Funds			$96 088.98

COMPARISON OF GENERAL FUNDS FOR FISCAL YEARS 1931–1935, INCLUSIVE

At Close of Fiscal Year	Assets				Liabilities			
	Cash	Investments[a]	Accounts Receivable and Miscellaneous	Furniture and Fixtures	Accounts Payable and Miscellaneous	Reserve for Book of Standards	Miscellaneous Funds[a]	Surplus
1931	$6 414.07	$49 946.21	$12 668.06	$6 571.94	$3 905.00	$5 690.70	$19 438.05	$46 566.53
1932	5 945.05	49 035.80	14 834.01	6 301.67	2 077.61	11 743.20	19 229.55	43 066.17
1933	7 869.45	38 266.50	16 739.78	6 092.51	3 178.98	....	19 008.68	46 780.58
1934	3 792.12	38 924.05	9 767.35	8 010.84	2 204.99	5 023.44	7 061.76	46 204.17
1935	10 514.73	36 180.42	9 220.39	7 489.70	2 695.60	10 023.44	7 061.76	43 624.44

[a] The funds reported in this column for 1931 to 1933, inclusive, include the principal of the A.S.T.M. Research Fund, which beginning with 1934 is no longer included under "General Funds."

RECEIPTS AND DISBURSEMENTS

FOR THE PERIOD JANUARY 1, 1935, TO DECEMBER 31, 1935

Cash balance, January 1, 1935			$3 792.12
RECEIPTS			
Operating Receipts (Budgeted):			
Dues and Entrance Fees:			
Current Dues	$64 633.01		
Past Dues	1 612.83		
Advance Dues	1 332.36		
Income, Life Membership Fund	150.00		
Entrance Fees	2 127.60		
Total Dues		$69 855.80	
Sale of Publications:			
Separate Standards	$5 847.51		
Book of Standards	6 739.66		
Book of Standards (Members, both parts)	284.00		
Book of Tentative Standards	5 538.54		
Proceedings	2 902.46		
Selected Standards for Students	676.40		
Special Reprints and Miscellaneous	16 092.85		
Total Sale of Publications		38 081.42	
Miscellaneous:			
Binding (Members)	$360.00		
Advertising, Bulletin	4 071.60		
Advertising, Index	1 149.00		
Authors' Reprints	208.16		
Interest on Deposits and Investments	2 607.60		
Registration and Other Fees, Annual Meeting	1 171.75		
A.S.T.M. Exhibit, Annual Meeting	2 168.50		
Committee A-1 for Technical Assistant	580.00		
Miscellaneous	103.26		
Total Miscellaneous Items		12 419.87	
Total Operating Receipts (Budgeted)		$120 357.09	
Non-Operating Receipts (Not Budgeted):			
Investments, Matured or Sold	$11 235.62		
Excess Remittances	45.33		
Accrued Interest	9.55		
International Association for Testing Materials, Dues	785.50		
Symposium on Effect of Temperature	1 062.43		
Committee C-1 for Technical Assistant	1 500.00		
Detroit Local Committee on Annual Meeting, for Refund to Contributors	329.25		
Total Non-Operating Receipts		14 967.68	
Total Receipts			135 324.77
Carried forward			$139 116.89

Brought forward			$139 116.89

DISBURSEMENTS

Operating Disbursements (*Budgeted*):

Publications:			
Year Book	$1 905.94		
Book of Standards	106.50		
Book of Standards Supplement	1 810.82		
Book of Tentative Standards	3 529.17		
Proceedings	19 162.48[a]		
Preprints	2 554.17		
Regional Meeting Papers	449.01		
Bulletin and Circular to Members	4 468.20		
Separate Standards	2 720.54		
Index to Standards and Tentative Standards	1 534.14		
Reprints (Reports, Papers, Symposiums, etc.)	8 570.78		
Miscellaneous Printing (Authors' Reprints, etc.)	432.39		
Total Disbursements, Publications		$47 244.14	
Salaries		44 912.50	
General Office Expenses		9 261.61	
Expenses, Standing and District Committees		2 795.35	
Expenses, Meetings and A.S.T.M. Exhibit		3 056.43	
Traveling Expenses, Administrative and Special Committees		2 037.28	
American Standards Assn. and Sectional Committees		1 000.00	
Rent, Headquarters		3 700.00	
Furniture and Fixtures		548.82	
Expenses of Exhibiting in Inform-a-Show and National Metals Congress		286.50	
Miscellaneous		151.12	
Total Operating Disbursements (Budgeted)		$114 993.75	

Non-Operating Disbursements (*Not Budgeted*):

Investments	$10 583.87		
Accrued Interest	96.18		
Refund of Excess Remittances	45.33		
International Assn. for Testing Materials	784.00		
Symposium on Effect of Temperature	306.76		
Technical Assistant, Committee C-1	1 463.02		
Detroit Local Committee on Annual Meeting, Refunded to Contributors	329.25		
Total Non-Operating Disbursements		13 608.41	
Total Disbursements			$128 602.16
Cash Balance December 31, 1935			$10 514.73

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[a] This amount includes $11,380.00 in the form of checks drawn against cost of *Proceedings*, but not actually paid on December 31, 1935, pending final completion of the publication work.

In addition to the general funds of the Society, the Secretary-Treasurer has on hand the following funds:

A.S.T.M. RESEARCH FUND

Principal Account:

	Total	*Invested*	*Uninvested Cash*
Balance January 1, 1935 as Reported	$8 179.35	$8 141.75	$37.60
Receipts—Proceeds Sale of Securities		−2 264.15	+2 264.15
		5 877.60	2 301.75
Disbursements—Purchase of Securities		+2 259.16	−2 259.16
		8 136.76	42.59
Loss on Sale of Securities	−773.35	−773.35	
Balance December 31, 1935	$7 406.00	$7 363.41	$42.59

The invested portion of the fund refers to cost of investments held.

Income Account:

Cash Balance, January 1, 1935	$1 588.53		
Receipts			
Interest on Deposits and Investments	396.25		
		$1 984.78	
Disbursements			
Joint Research Project with University of Illinois, on Speed of Testing	$600.00		
Research Committee on Yield Point	31.15		
Accrued Interest on Securities Purchased	37.12		
		$668.27	
Cash Balance, December 31, 1935			$1 316.51

DUDLEY MEDAL AND MARBURG LECTURE FUND

Balance, January 1, 1935:			
Principal—Investments (At Cost)	$6 625.00		
Income—Cash	566.69		
		$7 191.69	
Receipts			
Interest on Deposits and Investments		330.00	
			$7 521.69
Disbursements			
Honorarium, 1935 Lecturer		$200.00	
Cost of 1935 Medal		74.00	
Engrossing 1935 Lecture Certificate		3.25	
Tax on Checks		.02	
			277.27
Balance, December 31, 1935:			
Principal—Investments (At Cost)		$6 625.00	
Income—Cash		619.42	
			$7 244.42

COMMITTEE FUNDS

Committee A-1 on Steel	$958.16
Committee A-3 on Cast Iron	31.33
Committee A-5 on Corrosion of Iron and Steel	6 508.36
Committee A-5, Subcommittee X on Embrittlement Investigation	130.14
Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys	3 295.80
Committee B-6 on Die-Cast Metals and Alloys	337.81
Committee C-1 on Cement	967.85
Committee C-1, Cement Reference Laboratory	393.84
Committee C-9 on Concrete and Concrete Aggregates	639.47
Committee C-10 on Hollow Masonry Building Units	258.93
Committee C-18 on Natural Building Stones	.01
Committee D-1 on Preservative Coatings for Structural Materials	34.09

COMMITTEE FUNDS—*Continued*

Committee D-14 on Screen Wire Cloth	$14.17	
Joint Committee on Investigation of the Effect of Phosphorus and Sulfur in Steel	363.71	
A.S.A. Sectional Committee on Specifications for Cast-Iron Pipe and Special Castings	1 698.49	
A.S.A. Sectional Committee on Classification of Coals	1 084.65	
Total Committee Funds		$16 716.81
Accounted for as follows:		
Investments (At Cost)	$6 000.00	
Cash Balance, December 31, 1935	10 716.81	
		$16 716.81

INVESTMENTS, DECEMBER 31, 1935

Par Value:		Book Value	Market[1] Value
	GENERAL FUNDS		
$2 000	Penna. R. R. Bonds, Seconds, 5's due 1964	$2 000.00	$2 135.00
9 000	Baltimore & Ohio R. R. General and Refunding Bonds, 5's, Series F, due 1996	9 106.55	6 682.50
6 000	Missouri Pacific R. R. First and Refunding Mortgage Bonds, 5's, Series F, due 1977 (Defaulted September 1, 1933)	5 690.70	1 672.50
10 000	New York Central R. R. Refunding and Improvement Bonds, 5's, due 2013	5 108.55	8 037.50
3 000	American Telephone and Telegraph Co. S. F. Debenture Bonds, 5's, due 1960	3 159.75	3 390.00
500	Consolidated Gas Co. of New York Bonds, 5½'s, due 1945	531.00	523.13
4 000	New York, Chicago & St. Louis R. R. Refunding and Mortgage Bonds, Series C, 4½'s, due 1978	2 805.61	2 840.00
3 000	Southern Pacific Oregon Lines Bonds, Series A, 4½'s, due 1977	2 576.69	2 640.00
5 000	U. S. Treasury Note, 2¾'s, due 1936	5 201.57	5 135.94
$42 500		$36 180.42	$33 056.57
	A.S.T.M. RESEARCH FUND		
$1 500	Baltimore & Ohio R. R. General and Refunding Bonds, 5's, Series F, due 1996	$1 511.25	$1 113.75
1 500	Consolidated Gas Co. of New York Bonds, 5½'s, due 1945	1 593.00	1 569.38
2 000	New York, Chicago & St. Louis R. R. Refunding and Mortgage Bonds, Series C, 4½'s, due 1978	1 400.26	1 420.00
1 000	Southern Pacific Oregon Lines Bond, Series A, 4½'s, due 1977	858.90	880.00
2 000	First Mortgage Real Estate Bonds on 1315-1317 Spruce St., Philadelphia, 6's, due 1945	2 000.00	1 200.00
$8 000		$7 363.41	$6 183.13
	DUDLEY MEDAL AND MARBURG LECTURE FUND		
$500	Baltimore & Ohio R. R. General and Refunding Bonds, 6's, due 1995	$550.00	$423.75
6 000	Baltimore & Ohio R. R. General and Refunding Bonds, 5's, due 1995	6 075.00	4 485.00
$6 500		$6 625.00	$4 908.75
	COMMITTEE FUNDS		
$5 000	U. S. Treasury Bond, 2¾'s, due 1945	$5 000.00	$5 051.55
1 000	U. S. Treasury Bond, 2⅞'s, due 1960	1 000.00	1 000.00
$63 000		$6 000.00	$6 051.55
		$56 168.83	$50 200.00

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[1] Market Values, except on First Mortgage Real Estate Bonds on 1317 Spruce St., Philadelphia, on which there was no quotation, have been taken from the *Philadelphia Inquirer*, as of January 2, 1936.

special funds, both book and market values being given; and a comparison of the financial condition of the Society at the close of the past five years.

No account has been taken in the accompanying financial statement of the assets of the Society in the form of publications in stock, with the exception of the cost value, $1668.41, of the copies still in stock of the Joint A.S.M.E.-A.S.T.M. Symposium on Effect of Temperature on the Properties of Metals purchased by the Society from the joint account described in a previous report;[1] this amount is included in the statement of assets. The inventory of technical publications on June 1, 1936, may be summarized approximately as follows:

	NUMBER OF COPIES
Year Book	200
Proceedings	5 600
Index to Proceedings, 4 parts, each	300
Book of A.S.T.M. Standards: Part I, Metals	1 332
Book of A.S.T.M. Standards: Part II, Non-Metals	1 374
1934 Supplement to Book of Standards	1 340
1935 Supplement to Book of Standards	360
Book of A.S.T.M. Tentative Standards	288
Index to Standards and Tentative Standards	1 075
Selected Standards for Students in Engineering	1 550
Reprints of 505 Standards (approximate)	35 000
Symposium on Effect of Temperature on the Properties of Metals	460
Special Reprints (approximate)	22 000

1936 Finances.—Society operations for 1936 are based on a budget of receipts which anticipates continuation of the growth of membership experienced during the past year. However, in view of the uncertainty of the times the budget of receipts and disbursements has been set up on a tentative basis, subject to review and adjustment of disbursements within actual income supplemented by such reserve funds as it was felt might be appropriatedly used if required. Receipts from dues and entrance fees are estimated at $72,200; receipts from sales of publications are estimated at $40,300; miscellaneous receipts including interest on investments and advertising in the *Bulletin* and Index to Standards, are estimated at $10,250, bringing the total of estimated current receipts to $122,750. To this has been added $1600 from reserve, making a total estimated income of $124,350. The estimate for disbursements has been kept within the latter amount, making full provision for the publication of standards, tentative standards and committee reports, with only slight curtailment respecting technical papers and discussions and in the volume of preprinting. For the first time it has been possible to make a substantial appropriation for expansion of the *Bulletin*. Experience of the first five months has been definitely encouraging with respect to income from dues and publication sales and would indicate that the estimate of income for the year has been on a properly conservative basis.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 53 (1932).

The Executive Committee will review the budget during the annual meeting, at which time income for the year may be predicted with greater certainty and any necessary adjustments in expenditures determined.

Research Fund:

During the year the Executive Committee has found it possible to transfer the sum of $2500 from general reserve funds accumulated in recent years to the principal of the A.S.T.M. Research Fund. This sum represents part of the entrance fees of recent years which were temporarily held in a contingent reserve fund.

The Executive Committee would also call attention to the efforts of a special research fund committee, consisting of F. O. Clements, chairman, K. G. Mackenzie and H. F. Moore, which has addressed a letter to long-time members of the Society who in the words of the committee "have manifested their faithfulness and loyalty to A.S.T.M. in so many ways," suggesting that each member consider the feasibility of setting aside in his will a sum of money for the A.S.T.M. Research Fund, the principal of which is, of course, kept intact and the interest expended in sponsoring needed research projects. In making their appeal the committee stressed the fact that it was desirous of having as widespread participation in this plan as possible. A number of members have responded, saying that they have made a provision for such contribution in their wills, and a number of others are giving the matter consideration. Three members each contributed outright the sum of $100 to the principal of the fund, and other members have stated that they will make similar contributions when they are able to do so.

This is a very encouraging response to the appeal of the committee, which plans to continue this work and to solicit the cooperation of members of the Society. It is generally acknowledged that an active research fund of reasonable proportions will multiply greatly the usefulness of the Society.

Additions to the principal of the Fund made during the year bring the total to approximately $10,200.

Inter-Society and Other Cooperative Relationships:

The Society's activities have always and of necessity involved cooperative relationships with many other organizations, which proceed along well-established lines. During the year news items in the *Bulletin* have told of some of the activities in this direction and these hardly require mention here. There are, however, several happenings during the year that merit specific mention in this report.

Respecting American Standards Association matters, the Mechanical Standards Committee has been organized as a "divisional committee" in the departmentalization of A.S.A. activities described a year ago, having for its essential purpose the coordination of standardization activities in the mechanical industries. The Society has an important interest in the work of this committee, since A.S.T.M. is at work in so many of these industries and desires effectively to coordinate that work with the work of other organizations. H. H. Morgan is the Society's representative on the committee, with the Assistant Secretary as alternate. This committee replaces the former Mechanical Standards Advisory Council.

The Sectional Committee on Petroleum Products and Lubricants was organized in January, 1936, under the sponsorship of the Society. Nearly thirty national technical societies, trade and industrial associations and Governmental departments are represented on the committee, which has for its scope:

> Specifications, methods of test and nomenclature relating to crude petroleum and petroleum products (products derived in whole or in large part from petroleum) other than organic chemicals, products used medicinally, and road, paving, waterproofing and electrical insulating materials.

The committee will function essentially as a planning, coordinating and supervisory group, looking to the appropriate technical committees of the various member organizations for actual development of standards which it will consider for approval by A.S.A. as American Standard. A survey of current projects in this field is being made by the committee, covering such products as lubricants, Diesel and fuel oils, and gasoline. The Society's representatives on the committee are T. A. Boyd and T. G. Delbridge. Mr. Boyd is temporary chairman.

Plans for closer coordination of the standardization activities of the American Railway Engineering Association and A.S.T.M., mentioned in last year's report, have been carried out during the year. The A.R.E.A. has appointed representatives on ten committees of the Society, these representatives having been selected from the A.R.E.A. committees most directly interested in the field covered by the respective A.S.T.M. committees. In this way our committees will be directly informed of the views on materials specifications and tests of the A.R.E.A. committees responsible for similar work in their own organization, and will be in a still better position to provide requirements in A.S.T.M. standards that will meet the needs of the railroads. The operation of this plan will greatly facilitate the harmonizing of essential requirements in A.R.E.A. and A.S.T.M. specifications. The two societies are also cooperating in several sectional committee projects under A.S.A. procedure.

Arrangements have been completed with the American Society for Metals for A.S.T.M. to cooperate with that society in the development of its recommended practices for heat treatment of metals, by appointment of a representative on the A.S.M. Handbook Committee who will have the responsibility of bringing recommended practices to the attention of interested A.S.T.M. committees and soliciting their comments for the consideration of the Handbook Committee. John Howe Hall has been named as the representative. A number of our metals committees are actively concerned with specifications for heat-treated products, necessitating at times the inclusion of requirements for heat treatment practices, and it is believed the cooperative arrangement with the American Society for Metals, which has for some years been devoting its major attention to the field of heat treatment, will be of mutual advantage.

The Executive Committee, through a special committee comprising R. W. Crum, Stanton Walker and the Secretary-Treasurer, has been discussing with the appropriate officials of the American Concrete Institute the relationship between the activities of the two organizations, especially those dealing with the development of standard tests and specifications for concrete and its constituent materials and for concrete products. There has for some years been a certain amount of overlapping in the work of the two bodies, which, while not at all serious, has seemed in some respects to be unnecessary; and the executives of both A.C.I. and A.S.T.M. have felt that careful review of the whole situation would point the way to policies that would serve as effective guides in developing standardization work in this field to the better advantage of each society and the industries concerned. The discussions that have taken place have indeed been very helpful, and have led to substantial agreement respecting means of coordination of the standardization work of the two societies.

In brief, it has been agreed that the scope of A.S.T.M. work does not include the field of design and construction and that A.C.I. should handle all such matters as design, fabrication and construction of concrete structures, recommended practices for manufacture of concrete products, standards of shop practice, procedures for construction practice in concrete, engineering and architectural design, etc. Only in certain special cases may it be necessary for the A.S.T.M. in its standardization work to refer to matters of design and construction and the Society's position with respect to such special cases is being clarified by modification of Section 13 of the Regulations Governing Standing Committees mentioned earlier in this report. The action of the Executive Committee in discontinuing Committee C-2 on Reinforced Concrete and referring the A.S.T.M. Tentative Rules for Construction of Concrete and Reinforced Concrete Work to the A.C.I., as mentioned earlier in this report, is in line with this statement of policy. It is, furthermore, believed that the several A.S.T.M. specifications for curing concrete are essentially recommended practices in the field of design and construction rather than that of materials and it has been agreed that such work should be sponsored by A.C.I. and not A.S.T.M. At the appropriate time the necessary steps will be taken to turn this work over to the A.C.I.

It has been further agreed that the A.S.T.M. should sponsor (1) development of methods of test for concrete and concrete products and for the constituent materials of concrete, as well as for certain related materials such as materials used in curing; and (2) the development of standard specifications for the constituent materials of concrete and for concrete itself (subject to mutually satisfactory interpretation of the term "concrete") and for manufactured concrete products such as masonry units, pipe, tile, etc.,—so-called "over-the-counter" materials or products as distinguished from actual field construction of concrete. Naturally the A.C.I., by the very nature of the purposes for which it is organized, will continue to have an interest in all such tests and specifications, but in general they are prepared to leave it to the A.S.T.M. to develop the necessary standard tests and specifications.

Finally, it has been recognized that there are certain border-line cases where considerations of design and construction are intimately tied in with the problems of tests and specifications. In such cases, as well as with other jurisdictional questions that may arise from time to time, it has been agreed that the secretaries of the two societies will confer and initiate such conferences as the circumstances may indicate to be desirable.

The Society has become formally one of six bodies sponsoring the activities of the Joint Research Committee on Boiler Feed Water Studies, upon which the A.S.T.M. has been represented for a number of years by Max Hecht and F. N. Speller.

The Society will be represented at the Third World Power Conference, to be held in Washington, D. C., next September, by Vice-Presidents A. C. Fieldner and A. E. White.

Respectfully submitted on behalf of the Executive Committee,

H. S. VASSAR,
President.

C. L. WARWICK,
Secretary-Treasurer.

June, 1936

REPORT OF COMMITTEE A-1
ON
STEEL

The activities of Committee A-1 on Steel have been intensified during the past year and the committee reports with satisfaction the completion of several important projects and agreeable progress on others which are under way. Active work on the part of numerous subcommittees enables the committee to propose eight new tentative standards, the adoption as standard of fourteen tentative specifications and the adoption of numerous revisions in several standards.

Three series of meetings have been held during the year—the main committee and numerous subcommittees convening in June, 1935, at Detroit, Mich., and in March, 1936, at Pittsburgh, Pa. Group meetings of subcommittees were held in January of this year at Philadelphia, Pa. There was excellent attendance at all of these meetings and many constructive recommendations resulted.

Since the 1935 annual meeting, 13 new members have been elected and 4 resignations accepted, the committee membership now totaling 215, of whom 121 are classified as non-producers and 94 as producers; of the former 92 are consumer and 29 general interest members.

Two of the subcommittees have elected new chairmen for the term 1936 – 1938, Subcommittee II on Structural Steel for Bridges, Buildings and Rolling Stock, F. H. Frankland; and Subcommittee VI on Steel Forgings and Billets, W. M. Barr. The retiring chairman of Subcommittee II, Mr. A. W. Carpenter, has directed the work of this important subcommittee since 1922.

Tentative Standards and Revisions Approved During the Past Year:

Subsequent to the 1935 annual meeting, Committee A-1 on Steel presented to the Society on August 22, 1935, through Committee E-10 on Standards the recommendations listed below, all of which were accepted.[1]

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[1] In submitting these recommendations to Committee E-10 on Standards, Committee A-1 reported the following results of the letter ballot vote of a total of 141 ballots returned from a committee membership of 206: A 70 – 35 T, affirmative 82, negative 1, and 58 ballots marked "not voting"; A 87 – 35 T, affirmative 85, negative none, and 56 ballots marked "not voting"; A 178 – 35 T, affirmative 74, negative 2, and 65 ballots marked "not voting"; A 179 – 35 T, affirmative 65, negative none, and 76 ballots marked "not voting"; A 180 – 35 T, affirmative 77, negative 10, and 54 ballots marked "not voting"; A 181 – 35 T, affirmative 79, negative 1, and 61 ballots marked "not voting"; A 182 – 35 T, affirmative 74, negative 1, and 66 ballots marked "not voting"; A 183 – 35 T, affirmative 66, negative 2, and 73 ballots marked "not voting"; A 149 – 33 T, affirmative 78, negative none, and 63 ballots marked "not voting"; A 150 – 33 T, affirmative 77, negative 1, and 63 ballots marked "not voting"; A 109 – 34 T, affirmative 71, negative none, and 70 ballots marked "not voting"; A 157 – 34 T, affirmative 74, negative 1, and 66 ballots marked "not voting"; A 158 – 35 T, affirmative 71, negative 1, and 69 ballots marked "not voting"; A 7 – 34, A 9 – 34 and A 94 – 33, affirmative 79, negative 7, and 55 ballots marked "not voting"; A 83 – 34, affirmative 77, negative none, and 64 ballots marked "not voting"; A 70 – 33, affirmative 81, negative 1, and 59 ballots marked "not voting"; A 87 – 27, affirmative 85, negative none, and 56 ballots marked "not voting."

Tentative Specifications for:

Carbon-Steel Plates for Boilers and Other Pressure Vessels for Stationary Service (A 70 – 35 T), as a revision of and to supersede the existing Standard Specifications for Boiler and Firebox Steel for Stationary Service (A 70 – 33),
Carbon-Steel and Alloy-Steel Castings for Railroads (A 87 – 35 T), as a revision of and to supersede the existing Standard Specifications for Carbon-Steel Castings for Railroads (A 87 – 27),
Electric-Resistance-Welded Steel and Open-Hearth Iron Boiler Tubes (A 178 – 35 T),
Seamless Cold-Drawn Steel Heat-Exchanger and Condenser Tubes (A 179 – 35 T),
Carbon-Steel Castings for Miscellaneous Industrial Uses (A 180 – 35 T), as a tentative revision of the existing Standard Specifications for Carbon-Steel Castings (A 27 – 24),
Forged or Rolled Steel Pipe Flanges for General Service (A 181 – 35 T),
Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for Service at Temperatures from 750 to 1100 F. (A 182 – 35 T), and
Heat-Treated Carbon- and Alloy-Steel Track Bolts (A 183 – 35 T), as a tentative revision of the existing Standard Specifications for Quenched Carbon-Steel Track Bolts (A 50 – 33) and for Quenched Alloy-Steel Track Bolts (A 51 – 33).

Revision of Tentative Specifications for:

High Tensile Strength Carbon-Steel Plates for Pressure Vessels (Plates 2 in. and Under in Thickness) (A 149 – 33 T),
High Tensile Strength Carbon-Steel Plates for Fusion-Welded Pressure Vessels (Plates over 2 in. up to and Including 4 in. in Thickness) (A 150 – 33 T),
Cold-Rolled Strip Steel (A 109 – 34 T),
Alloy-Steel Castings for Valves, Flanges and Fittings for Service at Temperatures from 750 to 1100 F. (A 157 – 34 T), and
Seamless Alloy-Steel Pipe for Service at Temperatures from 750 to 1100 F. (A 158 – 35 T).

Tentative Revision of Standard Specifications for:

Steel for Bridges (A 7 – 34),
Steel for Buildings (A 9 – 34),
Structural Silicon Steel (A 94 – 33), and
Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 – 34).

Withdrawal of Standard Specifications for:

Boiler and Firebox Steel for Stationary Service (A 70 – 33), and
Carbon-Steel Castings for Railroads (A 87 – 27).

The new and revised tentative specifications and the tentative revisions appear in the 1935 *Proceedings*.[1]

Approval of A.S.T.M. Standards by American Standards Association:

During the year, three standard specifications under the jurisdiction of Committee A-1 have been approved as American Standard by the American Standards Association, as follows:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, pp. 527 to 622 and 1379 to 1384, incl. (1935); also 1935 Book of A.S.T.M. Tentative Standards, pp. 1 to 148 and 1505 to 1510, incl.

Standard Specifications for Billet-Steel Concrete Reinforcement Bars (A 15 - 35) (A.S.A. No. A50.1 - 1936),

Standard Specifications for Rail-Steel Concrete Reinforcement Bars (A 16 - 35) (A.S.A. No. A50.2 - 1936), and

Standard Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement (A 82 - 34) (A.S.A. No. A50.3 - 1936).

Data on Nominal Creep Strength.—Committee A-1 recommends to the Society that consideration be given to the publication of ther eport covering Data on Nominal Creep Strength of Steels at Elevated Temperatures[1] compiled by the Creep Data Section of Subcommittee XXII. This report presents the results of an undertaking to assemble all available data on alloy steels for high-temperature service corresponding to the compositions included in the specifications under consideration by Subcommittee XXII.

RECOMMENDATIONS AFFECTING STANDARDS

The recommendations of the committee affecting its standard and tentative specifications are listed first in summarized form for convenience; an analysis of the letter ballot on each item is given in Table I. Where necessary, these recommendations are referred to further, being grouped for convenience in the order of the subcommittees responsible for them.

I. Proposed Tentative Standards.—The committee recommends that the following proposed tentative specifications be accepted for publication as tentative as appended hereto:

Proposed Tentative Specifications for:

High-Carbon-Steel Joint Bars,[2]

Quenched Carbon-Steel Joint Bars,[3]

Structural Nickel Steel,[4]

Fabricated Steel Bar or Rod Mats for Concrete Reinforcement,[5]

Welded Steel Wire Fabric for Concrete Reinforcement,[6]

One-Wear and Two-Wear Wrought Steel Wheels,[7]

Seamless Alloy-Steel (4 to 6 per cent Chromium) Still Tubes for Refinery Service,[8] and

Seamless Cold-Drawn Alloy-Steel (4 to 6 per cent Chromium) Heat-Exchanger and Condenser Tubes.[9]

II. Proposed Revisions of Standards.—The committee recommends for immediate adoption revisions which have been incorporated in the Standard Specifications for Wrought Solid Carbon-Steel Wheels for Steam Railway Service (A 57 - 29), as appended hereto,[10] entitled "Specifications for Multiple-Wear Wrought-Steel Wheels." The committee accordingly asks for the necessary nine-tenths vote at the annual meeting in order that these revised specifications may be referred to letter ballot of the Society for immediate adoption.

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[1] Available as separate publication.
[2] See p. 579.
[3] See p. 583.
[4] See p. 561.
[5] See p. 571.
[6] See p. 575.
[7] See p. 592.
[8] See p. 619.
[9] See p. 612.
[10] See 1936 Book of A.S.T.M. Standards, Part I, p. 222.

III. Proposed Revision of Tentative Standards.—Revisions are recommended in the following tentative specifications, the revised specifications to be continued as tentative:

Tentative Specifications for Heat-Treated Carbon-Steel and Alloy-Steel Track Bolts (A 183 – 35 T), revised as proposed in the Appendix, and
Tentative Specifications for Carbon-Steel Castings for Miscellaneous Industrial Uses (A 180 – 35 T), revised as appended hereto.[1]

IV. Adoption of Tentative Standards as Standard.—The committee recommends that the following fourteen tentative standards be referred to letter ballot of the Society for adoption as standard with revisions in the seven specifications indicated, as given in detail in the Appendix:

Tentative Specifications for:

Axle-Steel Concrete Reinforcement Bars (A 160 – 35 T),[2]
Alloy-Steel Castings for Structural Purposes (A 148 – 33 T),[3] as revised,
Carbon-Steel and Alloy-Steel Castings for Railroads (A 87 – 35 T),[2]
Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses (A 120 – 34 T),[4]
Electric-Fusion-Welded Steel Pipe (Sizes 30 in. and Over) (A 134 – 32 T),[5]
Electric-Fusion-Welded Steel Pipe (Sizes 8 in. to but not Including 30 in.) (A 139 – 34 T),[4]
Carbon-Steel Plates for Boilers and Other Pressure Vessels for Stationary Service (A 70 – 35 T),[2] as revised,
High Tensile Strength Carbon-Steel Plates for Pressure Vessels (Plates 2 in. and Under in Thickness) (A 149 – 35 T),[2] editorial change,
High Tensile Strength Carbon-Steel Plates for Fusion-Welded Pressure Vessels (Plates over 2 in. up to and Including 4 in. in Thickness) (A 150 – 35 T),[2] as revised,
Lap-Welded and Seamless Steel Pipe for High-Temperature Service (A 106 – 34 T),[4]
Electric-Fusion-Welded Steel Pipe for High-Temperature and High-Pressure Service (A 155 – 34 T),[4]
Alloy-Steel Castings for Valves, Flanges and Fittings for Service at Temperatures from 750 to 1100 F. (A 157 – 35 T),[2] as revised,[6]
Seamless Alloy-Steel Pipe for Service at Temperatures from 750 to 1100 F. (A 158 – 35 T),[2] as revised,[6] and
Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for Service at Temperatures from 750 to 1100 F. (A 182 – 35 T),[2] as revised.[6]

Of these specifications, three (A 87 – 35 T, A 70 – 35 T and A 182 – 35 T) were approved for publication as tentative by Committee E-10 on Standards on August 22, 1935, and in order that they may be referred to letter ballot of the Society, Committee A-1 asks for the necessary nine-tenths vote at the annual meeting.

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[1] See p. 598.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, pp. 552, 561, 527, 534, 539, 597, 605, 616 (1935); also 1935 Book of A.S.T.M. Tentative Standards, pp. 26, 41, 1, 8, 13, 103, 111, 142.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 553 (1933); also 1935 Book of A.S.T.M. Tentative Standards, p. 35.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, pp. 604, 598, 637, 628 (1934); also 1935 Book of A.S.T.M. Tentative Standards, pp. 97, 72, 131, 122.

[5] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 560 (1932); also 1935 Book of A.S.T.M. Tentative Standards, p. 78.

[6] Revisions submitted at annual meeting, see Summary of Proceedings, pp. 17 to 19.

V. Adoption of Tentative Revisions of Standards as Standard.—The committee recommends that the revisions which have been previously published as tentative[1] in the following standards be approved for reference to letter ballot of the Society for adoption as standard:

Revision of Standard Specifications for:

Open-Hearth Carbon-Steel Rails (A 1 – 30),
Steel for Bridges (A 7 – 34), as amended,[2]
Steel for Buildings (A 9 – 34), as amended,
Structural Silicon Steel (A 94 – 33), as amended,
Structural Rivet Steel (A 141 – 33),
Structural Steel for Ships (A 131 – 33),
Carbon-Steel Bars for Railway Springs with Special Silicon Requirements (A 68 – 27),
Carbon-Steel Car and Tender Axles (A 21 – 27), as amended,
Quenched-and-Tempered Carbon-Steel Axles, Shafts and Other Forgings for Locomotives and Cars (A 19 – 27), as amended,
Quenched-and-Tempered Alloy-Steel Axles, Shafts and Other Forgings for Locomotives and Cars (A 63 – 27), as amended,
Wrought Solid Carbon-Steel Wheels for Electric Railway Service (A 25 – 24),
Welded and Seamless Steel Pipe (A 53 – 33),
Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 – 34),
Boiler Rivet Steel and Rivets (A 31 – 24),
Commercial Quality Hot-Rolled Bar Steels (A 107 – 33), as amended,
Commercial Cold-Finished Bar Steels and Cold-Finished Shafting (A 108 – 33), as amended,
Carbon-Steel Castings for Valves, Flanges and Fittings for High-Temperature Service (A 95 – 33), and
Forged or Rolled Steel Pipe Flanges for High-Temperature Service (A 105 – 33).

Amendments, as given in detail in the Appendix to this report, of the tentative revisions proposed in eight of the above specifications (A 7 – 34, A 9 – 34, A 94 – 33, A 107 – 33, A 108 – 33, A 21 – 27, A 19 – 27, A 63 – 27) are recommended by the committee, all of these amendments being germane to the original revisions. The committee asks for the necessary nine-tenths vote at the annual meeting in order that the revisions as amended in Specifications A 7 – 34, A 9 – 34, and A 94 – 33, approved as tentative by Committee E-10 on Standards on August 22, 1935, may be referred to letter ballot of the Society for adoption as standard.

VI. Withdrawal of Standards.—The withdrawal of the following nine existing standards[3] is recommended:

Standard Specifications for:

High-Carbon-Steel Splice Bars (A 5 – 14),
Quenched High-Carbon-Steel Splice Bars (A 49 – 21),

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, pp. 1371 to 1387 (1935); also 1935 Book of A.S.T.M. Tentative Standards, pp. 1497 to 1513.

[2] Additional revision submitted at annual meeting, see Summary of Proceedings, p. 19.

[3] 1933 Book of A.S.T.M. Standards, Part I, pp. 117, 120, 131, 135, 21, 229, 272, 269, 275.

Standard Specifications for (Continued):

Quenched Carbon-Steel Track Bolts (A 50 – 33),
Quenched Alloy-Steel Track Bolts (A 51 – 33),
Structural Nickel Steel (A 8 – 29),
Carbon-Steel Castings (A 27 – 24),
Carbon Tool Steel (A 71 – 26),
Alloy Tool Steel (A 115 – 28), and
High-Speed Tool Steel (A 92 – 26).

Comments on the withdrawal of the first six specifications appear later in this report under Activities of Subcommittees. The three specifications covering tool steels have existed for several years without revision. As the result of a questionnaire sent to each committee member, it was ascertained that the specifications were very little used, that to make them of service extensive revisions would be necessary, that the standardization of purchase requirements would be a very long and arduous task and finally, there was little demand that such work be undertaken. Accordingly, the withdrawal of these three specifications appears to be justified.

The recommendations appearing in this report have been referred to letter ballot of the committee which consists of 215 members, with the results shown in Table I.

ACTIVITIES OF SUBCOMMITTEES

Certain important features of the committee's work are discussed below, grouped in the order of the respective subcommittees responsible.

Subcommittee I on Steel Rails and Accessories (E. F. Kenney, chairman).—The two proposed tentative specifications covering joint bars, appended hereto,[1] are essentially extensive revisions of the existing Standard Specifications for High-Carbon-Steel Splice Bars (A 5 – 14) and for Quenched High-Carbon-Steel Splice Bars (A 49 – 21), and were developed jointly by Subcommittee I and the Track Committee of the American Railway Engineering Association. Divergent opinions on the allowable maximum camber in the vertical and horizontal plane resulted in a compromise with agreement being given to the values now incorporated in the revised specifications. Concurrently with the approval of the proposed specifications as tentative it is recommended the existing standards be withdrawn.

It was indicated when the Tentative Specifications for Heat-Treated Carbon- and Alloy-Steel Track Bolts (A 183 – 35 T), developed in joint cooperation with the A.R.E.A., were recommended in 1935, that they were essentially a revision and consolidation of the existing Standard Specifications for Quenched Carbon-Steel Track Bolts (A 50 – 33), and for Quenched Alloy-Steel Track Bolts (A 51 – 33), and would eventually supersede these standards. The withdrawal of the existing standards is now recommended.

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[1] See pp. 579 and 583.

TABLE I.—ANALYSIS OF LETTER BALLOT VOTE.

Items	Affirmative	Negative	Ballots Marked "Not Voting"
I. PROPOSED TENTATIVE STANDARDS			
Specifications for High-Carbon-Steel Joint Bars	59	1	84
Specifications for Quenched Carbon-Steel Joint Bars	59	1	84
Specifications for Structural Nickel Steel	82	0	62
Specifications for Fabricated Steel Bar or Rod Mats for Concrete Reinforcement	57	2	85
Specifications for Welded Steel Wire Fabric for Concrete Reinforcement	59	0	85
Specifications for One-Wear and Two-Wear Wrought Steel Wheels	58	0	86
Specifications for Seamless Alloy-Steel (4 to 6 per cent Chromium) Still Tubes for Refinery Service	68	0	76
Specifications for Seamless Cold-Drawn Alloy-Steel (4 to 6 per cent Chromium) Heat-Exchanger and Condenser Tubes	68	0	76
II. PROPOSED REVISION OF STANDARD			
Specifications for Wrought Solid Carbon-Steel Wheels for Steam Railway Service (A 57 – 29), immediate adoption	57	1	86
III. PROPOSED REVISION OF TENTATIVE STANDARDS			
Specifications for Heat-Treated Carbon-Steel and Alloy-Steel Track Bolts (A 183 – 35 T)	60	0	84
Specifications for Carbon-Steel Castings for Miscellaneous Industrial Uses (A 180 – 35 T)	83	1	60
IV. ADOPTION OF TENTATIVE STANDARDS AS STANDARD			
Specifications for Axle-Steel Concrete Reinforcement Bars (A 160 – 35 T)	60	1	83
Specifications for Alloy-Steel Castings for Structural Purposes (A 148 – 33 T), as revised	83	0	61
Specifications for Carbon-Steel and Alloy-Steel Castings for Railroads (A 87 – 35 T)	80	0	64
Specifications for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses (A 120 – 34 T)	77	0	67
Specifications for Electric-Fusion-Welded Steel Pipe (Sizes 30 in. and Over) (A 134 – 32 T)	80	0	64
Specifications for Electric-Fusion-Welded Steel Pipe (Sizes 8 in. to but not Including 30 in.) (A 139 – 34 T)	79	0	65
Specifications for Carbon-Steel Plates for Boilers and Other Pressure Vessels for Stationary Service (A 70 – 35 T), as revised	83	0	61
Specifications for High Tensile Strength Carbon-Steel Plates for Pressure Vessels (Plates 2 in. and Under in Thickness) (A 149 – 35 T), editorial change	82	1	61
Specifications for High Tensile Strength Carbon-Steel Plates for Fusion-Welded Pressure Vessels (Plates over 2 in. up to and Including 4 in. in Thickness) (A 150 – 35 T), as revised	80	0	64
Specifications for Lap-Welded and Seamless Steel Pipe for High-Temperature Service (A 106 – 34 T)	75	2	67
Specifications for Electric-Fusion-Welded Steel Pipe for High-Temperature and High-Pressure Service (A 155 – 34 T)	76	1	67
Specifications for Alloy-Steel Castings for Valves, Flanges and Fittings for Service at Temperatures from 750 to 1100 F. (A 157 – 35 T), as revised[a]	74	8	62
Specifications for Seamless Alloy-Steel Pipe for Service at Temperatures from 750 to 1100 F. (A 158 – 35 T), as revised	66	6	72
Specifications for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for Service at Temperatures from 750 to 1100 F. (A 182 – 35 T), as revised	69	5	70
V. ADOPTION OF TENTATIVE REVISIONS OF STANDARDS AS STANDARD			
Specifications for Open-Hearth Carbon-Steel Rails (A 1 – 30)	58	1	85
Specifications for Steel for Bridges (A 7 – 34), as amended	80	0	62
Specifications for Steel for Buildings (A 9 – 34), as amended	76	5	63
Specifications for Structural Silicon Steel (A 94 – 33), as amended	76	5	63
Specifications for Structural Rivet Steel (A 141 – 33)	91	1	52
Specifications for Structural Steel for Ships (A 131 – 33)	76	0	68
Specifications for Carbon-Steel Bars for Railway Springs with Special Silicon Requirements (A 68 - 27)	77	0	67
Specifications for Carbon-Steel Car and Tender Axles (A 21 – 27), as amended	72	0	72
Specifications for Quenched-and-Tempered Carbon-Steel Axles, Shafts and Other Forgings for Locomotives and Cars (A 19 – 27), as amended	68	0	76
Specifications for Quenched-and-Tempered Alloy-Steel Axles, Shafts and Other Forgings for Locomotives and Cars (A 63 – 27), as amended	68	0	76
Specifications for Wrought Solid Carbon-Steel Wheels for Electric Railway Service (A 25 – 24)	54	0	90
Specifications for Welded and Seamless Steel Pipe (A 53 - 33)	79	0	65
Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 – 34)	79	0	65
Specifications for Boiler Rivet Steel and Rivets (A 31 – 24)	78	2	64
Specifications for Commercial Quality Hot-Rolled Bar Steels (A 107 – 33), as amended	74	4	66
Specifications for Commercial Cold-Finished Bar Steels and Cold-Finished Shafting (A 108 – 33), as amended	70	4	70
Specifications for Carbon-Steel Castings for Valves, Flanges and Fittings for High-Temperature Service (A 95 – 33)	76	1	67
Specifications for Forged or Rolled Steel Pipe Flanges for High-Temperature Service (A 105 – 33)	75	2	67
VI. WITHDRAWAL OF STANDARDS			
Specifications for High-Carbon-Steel Splice Bars (A 5 – 14)	61	0	83
Specifications for Quenched High-Carbon-Steel Splice Bars (A 49 – 21)	61	0	83
Specifications for Quenched Carbon-Steel Track Bolts (A 50 – 33)	62	1	81
Specifications for Quenched Alloy-Steel Track Bolts (A 51 – 33)	62	1	81
Specifications for Structural Nickel Steel (A 8 – 29)	82	0	62
Specifications for Carbon-Steel Castings (A 27 – 24)	80	1	63
Specifications for Carbon Tool Steel (A 71 – 26)	82	0	59
Specifications for Alloy Tool Steel (A 115 – 28)	82	0	59
Specifications for High-Speed Tool Steel (A 92 – 26)	82	0	59

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[a] The classified vote on the adoption of the Tentative Specifications for Alloy-Steel Castings for Valves, Flanges and Fittings for Service at Temperatures from 750 to 1100 F. was as follows: Affirmative: 20 producers, 44 consumers, 10 general interests; negative: 6 producers, 1 consumer, 1 general interest.

Subcommittee II on Structural Steel for Bridges, Buildings and Rolling Stock (A. W. Carpenter, chairman).—The proposed revision of the Standard Specifications for Structural Nickel Steel (A 8 – 29), in the form of new tentative specifications appended hereto,[1] are recommended to supersede the existing standard when accepted for publication as tentative. The revised specifications provide for a nickel steel of higher strength than the existing standard, which can be attained and is desired in view of the present disproportionate ratios of cost and strength of nickel steel and silicon steel to the present standards. Requirements for nickel rivet steel have been omitted in line with the elimination of rivet steel from other structural steel specifications. The subcommittee expects to present in the near future a specification for high-strength structural rivet steel that can be used with structural silicon steel and equivalent steels.[2]

This subcommittee, in recommending a further amendment as given in the Appendix of the proposed revisions involving the finish clause of the Standard Specifications A 7, A 9 and A 94 covering respectively, Steel for Bridges and Buildings, and Silicon Steel, is reverting to the original form in which this amendment was first proposed, providing that an experienced mill inspector is to inspect the work after the chipping operation and that the purchaser's inspector is to be given full opportunity to make this same inspection.

Subcommittee V on Steel Reinforcement Bars (H. H. Morgan, chairman). —This subcommittee, which has experienced one of its most active years, has given detailed study to specification requirements covering various types of concrete reinforcement material, which work was undertaken at the request of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete. The proposed tentative specifications covering fabricated bar or rod mats and welded wire fabric are recommended for publication as tentative as appended hereto.[3] Further consideration is being given to the proposed specifications covering expanded metal reinforcement, a draft of which was studied by members of the committee. A special subgroup is developing separate specifications covering woven wire fabric, since the committee decided this material could not be properly included in the welded wire fabric specifications.

Subcommittee VI on Steel Forgings and Billets (R. W. Steigerwalt, chairman).—This subcommittee has two subgroups actively at work, one on alloy-steel forgings and the other on carbon-steel forgings. These groups are studying the specifications in the charge of Subcommittee VI including the Tentative Specifications for Normalized and Tempered Alloy-Steel Forgings for Locomotives (A 133 – 33 T). The committee believes it desirable to reduce the number of forging specifications if feasible but is cognizant that their workability and proper grades are of prime importance. The two subgroups will bring the specifications up to date, recommending any consolidation which in their opinion will be workable.

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[1] See p. 561.

[2] Subsequent to the annual meeting Committee A-1 presented these specifications as tentative to the Society through Committee E-10 on Standards, see Editorial Note, p. 77.—ED.

[3] See pp. 571 and 575.

Subcommittee VII on Rolled Steel Wheels and Steel Tires (R. W. Steigerwalt, chairman).—The proposed tentative specifications for one-wear and two-wear wrought steel wheels which are recommended for publication as tentative, as appended hereto,[1] cover wheels with $1\frac{1}{4}$-in. rim thickness which conform to the requirements of the Association of American Railroads, and in addition cover wheels with 2-in. rim thickness. The respective requirements for these wheels are very similar, the differences being in their design. Specification requirements covering the latter type of wheels are now being drafted by the A.A.R. The subcommittee in recommending the new specifications is meeting a persistent demand for standardized requirements for this material.

In order to bring the carbon content and tolerance for wheels for tender and passenger car service in line with corresponding requirements of the A.A.R., revisions are proposed for immediate adoption in the Standard Specifications for Wrought Solid Carbon-Steel Wheels for Steam Railway Service (A 57 – 29). The changes have been incorporated in the Specifications for Multiple-Wear Wrought-Steel Wheels, appended hereto.[2]

Subcommittee VIII on Steel Castings (W. C. Hamilton, chairman).—This subcommittee, through a special section headed by R. A. Bull, developed two tentative specifications which were approved through Committee E-10 procedure in August, covering Tentative Specifications for Carbon-Steel Castings for Miscellaneous Industrial Uses (A 180 – 35 T) and Tentative Specifications for Carbon-Steel and Alloy-Steel Castings for Railroads (A 87 – 35 T). Revisions are proposed in the former and the specifications in their completely revised form are appended hereto.[3] The proposed revisions amplify the specifications in the following manner: Restricting the tensile properties now listed for annealed material so that they will apply exclusively to normalized materials, except as the producer may elect to develop by full annealing the properties specified for normalized castings; and adding as new matter, tension test requirements for three new grades, specified to be full annealed. Other changes have been made in the draft, as required by the modifications mentioned.

The inclusion of a full-annealed grade required to have a tensile strength of not less than 66,000 lb. per sq. in. has been listed at the request of producers and purchasers of castings for bridges. Considerable correspondence has been exchanged with the subgroup of the American Railway Engineering Association concerned with this material and this has resulted in the specifying of tensile requirements that are satisfactory to the interested A.R.E.A. section. Valuable cooperation was given the Subcommittee VIII section by the Committee on Specifications of the Steel Founders' Society of America, and by the A.R.E.A. subcommittee.

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[1] See p. 592.

[2] See 1936 Book of A.S.T.M. Standards, Part I, p. 222.

[3] See p. 598.

Action was taken by Subcommittee VIII to recommend assigning to the revised specifications the serial designation A 27 in place of A 180, and to withdraw the existing Standard Specifications A 27 – 24 which are now considered obsolete.

The Tentative Specifications for Carbon-Steel and Alloy-Steel Castings for Railroads (A 87 – 35 T) and the Tentative Specifications for Alloy-Steel Castings for Structural Purposes (A 148 – 33 T) are proposed for adoption as standard. Revisions, given in the Appendix, are recommended for immediate incorporation in the latter specifications.

Subcommittee IX on Steel Tubing and Pipe (T. G. Stitt, chairman).—This subcommittee has given detailed study at several meetings to the large number of specifications for pipe and tubing in its charge and is making numerous recommendations in connection with them as detailed in the first part of this report. Continuing its work in the development of requirements for steel still tubes for refinery service and heat-exchanger and condenser tubes, two proposed specifications covering 4 to 6 per cent chromium alloy steel products are recommended for publication as tentative. These specifications appended hereto,[1] were developed by the same joint committee, consisting of representatives of the American Petroleum Institute and Subcommittee IX, which developed the specifications approved as tentative last year covering seamless cold-drawn carbon-steel tubes.

As a result of active consideration concerning the necessity of additional requirements concerning long-length and heavy-wall boiler tubes which might be ordered in accordance with the Standard Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 – 34), a special subgroup has been studying the situation and expects to report new specifications to cover special heavy-wall long-length tubes for high-pressure boilers.[2] Editorial changes as given in the Appendix are recommended in Specifications A 83.

Subcommittee XI on Boiler Steel (E. J. Edwards, chairman).—In addition to recommendations as previously listed concerning certain of its specifications, Subcommittee XI has prepared editorial changes in the titles and scope clauses of the three specifications covering various types of steel plates for boiler and pressure vessels A 70, A 149 and A 150. These changes, as given in the Appendix, are intended to clarify the intended use of the specifications.

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[1] See pp. 612 and 619.

[2] Subsequent to the annual meeting Committee A-1 presented these specifications as tentative to the Society through Committee E-10 on Standards, see Editorial Note, p. 77.—ED.

Subcommittee XIII on Methods of Physical Testing (L. H. Fry, chairman).—Recommendations on the part of this subcommittee resulted in the decision of the Advisory Committee of Committee A-1 on Steel to recommend that "all specifications under the jurisdiction of Committee A-1 shall contain a complete description of the respective test specimens required." It is intended that this recommendation shall not be retroactive, but shall go into effect in the respective specifications whenever feasible. Subcommittee XIII, which has as its function the harmonizing of physical methods of testing specified in the Steel Committee's specifications, has given active consideration to numerous problems during the year. The committee was represented at the Pittsburgh meeting of the Section on Speed of Testing of Committee E-1 on Methods of Testing, having previously discussed in detail the question of proper methods for limiting the speed for the determination of yield point.

Subcommittee XIII recommends that the Tentative Method of Bend Testing for Ductility of Metals (E 16 – 31 T) which is in the jurisdiction of Committee E-1 on Methods of Testing be not adopted as standard without further consideration being given by Committee E-1 to the well established methods of bend tests which have for years been embodied in the standard acceptance specifications of A-1. Subcommittee XIII believes that it should be made clear that Tentative Method E 16 is a test method intended for special purposes and is not intended to replace or to invalidate the bend test methods in use in the A-1 specifications.

Subcommittee XV on Commercial Bar Steels (J. J. Shuman, chairman).—In proposing additional amendments, given in the Appendix, to the revisions of the Standard Specifications for Commercial Quality Hot-Rolled Bar Steels (A 107 – 33) and for Commercial Cold-Finished Bar Steels and Cold-Finished Shafting (A 108 – 33), the subcommittee is abandoning the idea of listing all S.A.E. grades and has set up grades known to be in relatively wide commercial demand, including two grades of resulfurized nut stock. In determining which grades should be included, a survey of grades carried in stock by members of the American Steel Warehouse Association was given due weight. Grade designations have been simplified and a number of changes in chemical and check analysis limits have been agreed upon.

Subcommittee XIX on Sheet Steel and Steel Sheets (A. L. Davis, chairman).—At its meeting in January, Subcommittee XIX held a topical discussion on "fine grained" steels. Valuable written and oral contributions were made and the following points were brought out:

1. The introduction of so-called "fine grained" steel (inherent) into commercial application in cold-rolled strip and sheet steel is still in an early stage, and verified data are meager. Nevertheless, its use is increasing.

2. When talking about grain size, it is necessary to distinguish between the

"actual," or *de facto*, grain size, and the "inherent" grain size. Thus, with ordinary rimmed steel we may have cold-rolled steel of remarkably fine grain, due to its history of processing. Actually, cold-rolled strip steel generally is of rather fine grain, as supplied by the producer. Thus, a fully killed steel of inherently fine grain may not be notably finer in grain size than the usual rimmed steel, though it is always somewhat finer.

3. Inherent grain size corresponds to the austenitic grain size resulting from a specified heat treatment. It will be modified by subsequent hot work and by cold work, and also by annealing. Thus, the *de facto* grain size in commercial cold-rolled sheets and strip steel does not necessarily indicate the inherent grain size. We do not know to what extent the superimposed effects of hot and cold work and annealing overshadow the inherent properties of the steel.

4. Today, several producers are in a position to furnish inherently fine grained, fully killed, pre-aged, or stabilized steel in sheet or strip, but such material is somewhat more costly to make, and hence is not furnished where ordinary rimming steel gives satisfaction.

5. Other things being equal, the finer the grain the smoother the surface of the formed part made therefrom. Likewise, the finer the grain size of the base metal under an electro-deposited plate, the finer the structure of the deposited coat, and the easier it is to bring up the luster in the final coloring operation. It is also true that the finer the grain, the higher the yield pressure and the greater the force required for stamping, drawing, etc., but this is not a serious objection for forming, and drawing, of moderate depth. On the other hand, for deep drawing and forming this greater resistance to deformation is apt to be an obstacle.

6. Some of the members of the subcommittee are making a study of the relationship of *de facto* grain size to the suitability for certain types of work, and also a correlation of this with other physical values ordinarily determined. It was the unanimous opinion that there is no present demand for incorporation of grain size into specifications and even if there were the time is not ripe for it. In any case, a considerable period of study and accumulation of data must intervene.

Subcommittee XXI on Steel for Welding (N. L. Mochel, chairman).—At the lengthy and well attended meeting of Subcommittee XXI in Pittsburgh in March there was presented a draft of proposed specifications covering iron and steel filler metal (arc-welding electrodes and gas-welding rods). This has been developed jointly with representatives of the American Welding Society. Extended discussion resulted in actions to change various portions of the draft and further consideration is being given to specification requirements through a special subgroup.

The subgroup studying the question of carbon and manganese limitations in steel for welding will attempt to procure material so that a series of tests may be made to develop essential data.

Subcommittee XXII on Valves, Fittings, Piping and Flanges for High-Temperature Service (A. E. White, chairman).—This subcommittee has continued its very active program and some evaluation of its work is indicated by numerous recommendations it has initiated as covered in this report. Particular attention has been given during the past year to specification requirements covering nuts for high-temperature or high-pressure service, or both, and requirements for alloy-steel bolting material for high temperatures and pressures. Specifications covering carbon and alloy-steel nuts have been prepared and submitted to letter ballot of Subcommittee XXII with the following results: Affirmative, 21; affirmative, with reservations, 8; negative, 2; ballots marked "not voting," 5. After composing minor points of disagreement, it is hoped to submit these proposed specifications to Committee A-1 and subsequently to the Society for approval as tentative.[1] With regard to the proposed specifications for alloy-steel bolting material for high-temperature service, substantial agreement has been reached except on the physical properties and chemical analysis of individual steels, which differences the subcommittee hopes to compose shortly so as to be able to recommend approval as tentative.[1] A number of revisions have been effected in the specifications for alloy-steel pipe, castings, and forgings.

In receiving the report of its Creep Data Section (H. J. Kerr, chairman), this subcommittee at its Pittsburgh meeting unanimously adopted a resolution "expressing the appreciation of Subcommittee XXII for the extensive compilation of creep data[2] made by that section in the face of manifest difficulties in obtaining adequate information about the numerous steels covered by its report. Particular credit is due P. E. McKinney, secretary of the Creep Data Section and to his associate, A. C. Chamberlain, of the Bethlehem Steel Co. for the large amount of effort and time expended in compiling and tabulating these data." The consensus of opinion was enthusiastic for continuing the collection of high-temperature data and eventually presenting creep values as log-log graphs which can be used by designing engineers as a basis for selecting safe working stresses to suit the service temperature. The need for collecting high-temperature data concerning corrosion resistance and embrittlement was also recognized.

The election of officers for the ensuing term of two years resulted in the re-election of the present incumbents.

This report has been submitted to letter ballot of the committee which consists of 215 members; 115 members returned their ballots, of whom 108 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

H. H. MORGAN,
Chairman.

H. P. BIGLER,
Secretary.

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[1] Subsequent to the annual meeting Committee A-1 presented these specifications as tentative to the Society through Committee E-10 on Standards, see Editorial Note, p. 77.—ED.

[2] Available as separate publication.

EDITORIAL NOTE

Subsequent to the annual meeting, Committee A-1 on Steel presented to the Society on August 26, 1936, through Committee E-10 on Standards the following new tentative specifications:

Proposed Tentative Specifications for:

Seamless Steel Boiler Tubes for High-Pressure Service,

Alloy-Steel Bolting Materials for High-Pressure and High-Temperature Service to 1100 F.,

Carbon and Alloy-Steel Nuts for Bolts for High-Pressure and High-Temperature Service to 1100 F., and

High-Strength Structural Rivet Steel.

The above specifications were accepted by Committee E-10 and appear on pp. 606, 627, 634 and 567, respectively.

APPENDIX

PROPOSED REVISIONS IN STANDARDS AND TENTATIVE STANDARDS FOR STEEL

In this Appendix are given proposed revisions in specifications covering steel and steel products as referred to earlier in this report. In connection with each title is given the reference to the publication in which the specifications appear in their present form.

Proposed Revisions of Tentative Standards

Proposed Revision of Tentative Specifications for Heat-Treated Carbon-Steel and Alloy-Steel Track Bolts (A.S.T.M. Designation: A 183 – 35 T):[1]

Section 3.—Change Paragraph (*b*) of this section from its present form: namely,

> (*b*) The steel for the nuts shall conform to the screw-steel grades of the Standard Specifications for Commercial Quality Hot-Rolled Bar Steels (A.S.T.M. Designation: A 107 – 33) of the American Society for Testing Materials.

to read as follows:

> (*b*) The steel for the nuts shall conform to the commercial quality of hot-rolled nut bar steel, and shall have a carbon range of from 0.15 to 0.25 per cent for open-hearth steel, 0.08 to 0.16 per cent for bessemer steel.

Proposed Revision of Tentative Specifications for Alloy-Steel Castings for Structural Purposes (A.S.T.M. Designation: A 148 – 33 T):[2]

Section 5.—Add the following Note 4 at the end of Section 5:

> Note 4.—The prescription of definite composition types of steel to meet the various physical requirements outlined in these specifications is not to be recommended, except by mutual agreement between the purchaser and manufacturer. It is to be observed that there are at present approximately 70 available types of alloy cast steel, many of which can be made to conform to the tensile requirements of a grade in any class listed in these specifications, merely by selection of heat treatment. For many purposes a wide latitude is therefore possible in the choice of composition.

Section 8.—In Paragraph (*a*) change the specified minimum reduction of area for Class C, Grade 1 from the present minimum value of "50 per cent" to a minimum value of "45 per cent."

Section 14.—Change Paragraph (*b*) to read as follows by the addition of the italicized words and the omission of those in brackets:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 556 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 30.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 553 (1933); also 1935 Book of A.S.T.M. Tentative Standards, p. 35.

(*b*) Defects which do not impair the strength of the castings may be welded by an approved process. The defects shall be cleaned out to solid metal before welding, and when required by the purchaser's inspector shall be submitted to him in this condition for approval. [Also when required by the purchaser's inspector,] Castings shall be given a simple and uniform heat treatment to relieve [cooling] stresses after welding, *unless otherwise agreed upon by the purchaser and manufacturer.*

New Section.—Add the following as a new Section 15, renumbering the remaining sections accordingly:

15. *Marking.*—The manufacturer's name or identification mark and the specified pattern number shall be cast on all castings, excepting those of such small size as to make such marking impracticable. In addition, the numbers of the melts used for pouring the castings may be stamped on all castings individually weighing 300 lb. or more. (Note 5.)

Note.—Add the following Note 5 at the end of the new Section 15:

NOTE 5.—The resistance of a sand mold to the erosive effect of inflowing metal is aided by smooth mold surfaces. Cast identification marks are formed by making indentations on the face of the mold. For the prevention of small defects caused by dislodged particles of molding sand there should be provided the minimum feasible number of cast identification marks.

Proposed Revision of Tentative Specifications for Carbon-Steel Plates for Boilers and Other Pressure Vessels for Stationary Service (A.S.T.M. Designation: A 70 – 35 T):[1]

Title.—Change editorially to read as follows by the addition of the italicized word and the omission of those in brackets:

Tentative Specifications for Carbon-Steel Plates for *Stationary* Boilers and Other Pressure Vessels [for Stationary Service].

Section 1.—Change this section editorially from its present form: namely,

1. These specifications cover two classes of steel for boilers and other pressure vessels for stationary service, namely: flange and firebox, and are intended to apply to plates, $\frac{3}{16}$ to 4 in., inclusive, in thickness.

to read as follows:

1. These specifications cover carbon-steel plates up to 4 in., inclusive, in thickness; of flange and firebox qualities; for boilers for stationary service and other pressure vessels. This material is suitable for fusion welding.

Section 3.—Change Paragraph (*a*) to read as follows by the addition of the italicized sentence:

3. (*a*) Plates over 2 in. in thickness, before being fabricated, shall be uniformly heat treated to produce grain refinement. *Heat treatment involving quenching in a liquid medium is not permitted.* If this treatment is not done at the rolling mill the testing shall be carried out in accordance with Paragraph (*b*).

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 527 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 1.

Section 4.—Change this section to provide that the maximum permissible carbon in firebox quality steel plates over 2 to 4 in., inclusive, in thickness shall be "0.30 per cent" instead of the present "0.33 per cent."

Proposed Revision of Tentative Specifications for High Tensile Strength Carbon-Steel Plates for Fusion-Welded Pressure Vessels (Plates over 2 in. up to and Including 4 in. in thickness) (A.S.T.M. Designation: A 150 – 35 T):[1]

Title.—Change editorially to read as follows by the addition of the italicized words and the omission of those in brackets:

> Tentative Specifications for High Tensile Strength Carbon-Steel Plates for Fusion-Welded Pressure Vessels (Plates over 2 in. [up to and Including] *to* 4 in., *Inclusive,* in Thickness).

Section 1.—Change this section editorially from its present form: namely,

> 1. These specifications cover two grades of high tensile strength carbon-steel plates over 2 in. and up to and including 4 in. in thickness of firebox quality, suitable for fusion-welded pressure vessels. The term grade is used to distinguish between different tensile ranges.

to read as follows:

> 1. These specifications cover two grades of high tensile strength carbon-steel plates over 2 in. to 4 in., inclusive, in thickness; of firebox quality; for fusion-welded boilers and other pressure vessels. The term grade is used to distinguish between different tensile ranges.

Section 3.—Make the same change in Paragraph (*a*) as is recommended in Section 3 of Specifications A 70 – 35 T above.

Editorial Revision of Tentative Specifications for High Tensile Strength Carbon-Steel Plates for Pressure Vessels (Plates 2 in. and Under in Thickness) (A.S.T.M. Designation: A 149 – 35 T):[1]

Section 1.—Change editorially to read as follows by the addition of the italicized sentence:

> 1. These specifications cover two grades of high tensile strength carbon-steel plates [$\frac{3}{16}$ in.] *up* to 2 in., inclusive, in thickness, of flange and firebox qualities, for boilers and other pressure vessels. *This material is suitable for fusion welding.* The term grade is used to distinguish between different tensile ranges.

Tentative Specifications for Alloy-Steel Castings for Valves, Flanges and Fittings for Service at Temperatures from 750 to 1100 F. (A 157 – 35 T):[1]

Section 5.—In the table of chemical requirements following this section make the following changes in Grades C6, C9 and C10:

Grade C6.—Change the manganese content from "1.00 max. per cent" to read "0.75 max. per cent."

Grade C9.—Change the nickel content from "8.00 to 10.30 per cent" to read "8.00 min. per cent"; also change the chromium content from "17.5 to 20.0 per cent" to read "18.00 min. per cent."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, pp. 539, 534, 597 (1935); also 1935 Book of A.S.T.M. Tentative Standards, pp. 13, 8, 103.

Add the following as an explanatory footnote "a" in connection with Grade C9:

[a] For the more severe general corrosive conditions, and when so specified, the carbon content shall not exceed 0.07 per cent.

The addition of such elements as molybdenum, tungsten, titanium, columbium and vanadium for purposes of stabilization shall be a matter of agreement between the manufacturer and the purchaser.

When the purchaser requires free-machining or better non-seizing, non-galling properties, the composition may contain suitable combinations of selenium and phosphorus or molybdenum and sulfur:

Selenium and Phosphorus	Selenium, per cent	0.20 to 0.35
	Phosphorus, max., per cent	0.17
Molybdenum and Sulfur	Molybdenum, per cent	0.40 to 0.80
	Sulfur, per cent	0.20 to 0.40

Grade C10.—Change the chromium content from "7.00 to 9.00 per cent" to read "8.00 to 10.00 per cent."

Section 8.—In the tabulation of tensile properties, change the column heading "yield strength" to read "yield point."

Section 8 (c).—Change to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

(*c*) *The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine, or by the use of dividers, at a crosshead speed not to exceed 1/8 in. per min. Where a definite yield point is not exhibited* the yield strength [shall correspond] *corresponding* to a limiting permanent set of 0.2 per cent of the gage length of the specimen *shall be used instead.* The "set method" of determining yield strength as described in the Standard Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8) of the American Society for Testing Materials shall be followed. The tensile strength shall be determined at a crosshead speed of not to exceed 1½ in. per min.

Section 9 (b).—Change to read as follows by the addition of the italicized words and figures:

(*b*) When a bend test is specified, the test specimens *for all grades excepting Grade C9, in which case the bending shall be through an angle of 120 deg.*, shall stand being bent cold through an angle of 90 deg. around a pin 1 in. in diameter, without cracking on the outside of the bent portion.

Section 10.—Add the following as a new Paragraph (*c*) to this section:

(*c*) Bend test specimens, when specified, shall be machined to 1 by ½ in. in section with the long edges rounded to a radius of not over $\frac{1}{16}$ in.

Tentative Specifications for Seamless Alloy-Steel Pipe for Service at Temperatures from 750 to 1100 F. (A 158 - 35 T):[1]

Section 6.—In the tabulation of chemical requirements make the following changes in Grades P1, P2, P3, P11, P12, P6, P8 and P9:

Grades P1 and P2.—Change the sulfur content from "0.045 max. per cent" to read "0.05 max. per cent."

Grade P3.—Change the phosphorus content from "0.03 max. per cent" to read "0.04 max. per cent"; also change the sulfur content from "0.04 max. per cent" to read "0.05 max. per cent."

Grade P11.—Change the phosphorus content from "0.03 max. per cent" to read "0.04 max. per cent"; also change the sulfur content from "0.03 max. per cent" to read "0.05 max. per cent."

Grade P12.—Change the manganese content from "0.30 to 0.60 per cent" to read "0.40 to 0.70 per cent"; also change the sulfur content from "0.045 max. per cent" to read "0.05 max. per cent."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 605 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 111.

Grade P6.—Change the phosphorus content from "0.025 max. per cent" to read "0.03 max. per cent"; also change the sulfur content from "0.025 max. per cent" to read "0.03 max. per cent."

Grades P8 and P9.—Change the silicon content from "0.70 max. per cent" to read "0.75 max. per cent."

Change footnote "a" to the table to read as follows by the addition of the italicized word and the omission of the words in brackets:

> Either molybdenum or tungsten [may] *shall* be used [if desired].

Add the following as a footnote to Section 6:

> The list is incomplete and will be reviewed annually and revised promptly when necessary.

Tentative Specifications for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for Service at Temperatures from 750 to 1100 F. (A 182 – 35 T):[1]

Section 8.—In the tabulation of chemical requirements make the following changes in Grades F1, F3, F4, F5, F7 and F11:

Grade F1.—Change the sulfur content from "0.045 max. per cent" to read "0.05 max. per cent."

Grade F3.—Change the sulfur content from "0.04 max. per cent" to read "0.05 max. per cent."

Grade F4.—Change the phosphorus content from "0.05 max. per cent" to read "0.04 max. per cent"; also change the manganese content from "0.40 to 0.70 per cent" to read "0.50 to 0.80 per cent"; also change the chromium content from "0.55 to 0.85 per cent" to read "0.50 to 0.80 per cent."

Grade F5.—Change the phosphorus content from "0.04 max. per cent" to read "0.03 max. per cent"; also change the sulfur content from "0.04 max. per cent" to read "0.03 max. per cent"; also change the molybdenum content from "0.40 to 0.60 per cent" to read "0.45 to 0.65 per cent"; also change the tungsten content from "0.80 to 1.25 per cent" to read "0.75 to 1.25 per cent."

Grade F7.—Change the carbon content from "0.25 to 0.40 per cent" to read "0.25 to 0.35 per cent"; also change the manganese content from "0.40 to 0.85 per cent" to read "0.40 to 0.60 per cent"; also change the phosphorus content from "0.05 max. per cent" to read "0.04 max. per cent"; also change the chromium content from "0.75 to 1.10 per cent" to read "0.80 to 1.10 per cent."

Grade F11.—Change the phosphorus content from "0.05 max. per cent" to read "0.04 max. per cent."

Proposed Revisions of Standards

Proposed Revision of Standard Specifications for Steel for Bridges (A.S.T.M. Designation: A 7 – 34):[2]

Section 1 (a).—Change to read as follows by the addition of the italicized words and figures and the omission of the words in brackets:

1 (*a*) Steel Castings.—The [Standard] *Tentative* Specifications for Carbon Steel Castings *for Miscellaneous Industrial Uses* (A.S.T.M. Designation: A 27 – *36 T*) of the American Society for Testing Materials, shall govern the purchase of steel castings for bridges. Unless otherwise specified, [class B castings, medium grade] *Grade B-1 castings, fully annealed,* shall be used.

Section 13.—An amendment of the existing tentative revision[3] of this section is proposed by the addition of the italicized words and the omission of those in brackets; the complete revision, which is to be added as Paragraph (*b*), lettering the present section as Paragraph (*a*), reads as follows:

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[1] *Proceedings,* Am. Soc. Testing Mats., Vol. 35, Part I, p. 616 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 142.

[2] 1934 Supplement to Book of A.S.T.M. Standards, p. 1.

[3] *Proceedings,* Am. Soc. Testing Mats., Vol. 35, Part I, p. 1379 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 1505.

(*b*) Surface imperfections that do not affect the full utility of the pieces, shall not be considered as injurious defects in structural shapes, $\frac{3}{8}$ in. or more in thickness. Such pieces may be processed by the following methods in order to give them a workmanlike finish:

(*1*) When the surface imperfections are less than $\frac{1}{16}$ in. in depth, they may be removed by grinding.

(*2*) When the surface imperfections are $\frac{1}{16}$ in. or more in depth, the pieces may be subjected to chipping and welding under limiting conditions as follows:

The cross-sectional area of any piece shall not be reduced more than 1.5 per cent at any point, nor shall the total area of the chipped surface of any piece exceed 2 per cent of the total surface area of that piece.

After any imperfection has been completely removed, the maximum depth of depression shall not exceed the following:

THICKNESS OF MATERIAL, IN.	DEPTH OF DEPRESSION, MAX., IN.
$\frac{3}{8}$ up to $\frac{1}{2}$	$\frac{1}{16}$
$\frac{1}{2}$ up to 1	$\frac{1}{8}$
1 up to $1\frac{1}{4}$	$\frac{3}{16}$
$1\frac{1}{4}$ up to $2\frac{1}{4}$	$\frac{1}{4}$
$2\frac{1}{4}$ up to $3\frac{1}{2}$	$\frac{3}{8}$

[The chipping and welding shall be performed under constant control by the manufacturer.] *An experienced mill inspector shall inspect the work after the chipping operation to see that the defects have been completely removed and that the limitations specified above have not been exceeded. The inspector representing the purchaser shall be given full opportunity to make this same inspection.* All welding shall be done be qualified welders using suitable coated welding rods. The welds shall be sound; the weld metal being thoroughly fused on all surfaces and edges without undercutting or overlap. Weld metal shall project at least $\frac{1}{16}$ in. above the rolled surface after welding, and the projecting metal shall be removed by chipping or grinding to make it flush with the rolled surface and produce a workmanlike finish.

Proposed Revision of Standard Specifications for Steel for Buildings (A.S.T.M. Designation: A 9 – 34):[1]

Section 13.—Make the same change in this section as recommended in Section 13 of Specifications A 7 – 34, above.

Proposed Revision of Standard Specifications for Structural Silicon Steel (A.S.T.M. Designation: A 94 – 33):[2]

Section 14.—Make the same change in this section as recommended in Section 13 of Specifications A 7 – 34, above.

Proposed Revision of Standard Specifications for Carbon-Steel Car and Tender Axles (A.S.T.M. Designation: A 21 – 27):[3]

Section 3.—An amendment of the existing tentative revision[4] in the table of chemical requirements is proposed involving changing the proposed revised range in manganese content from "0.40 to 0.90 per cent" to read "0.50 to 0.90 per cent."

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[1] 1934 Supplement to Book of A.S.T.M. Standards, p. 9.

[2] 1933 Book of A.S.T.M. Standards, Part I, p. 30.

[3] 1933 Book of A.S.T.M. Standards, Part I, pp. 175, 180.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1375 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 1501.

Proposed Revision of Standard Specifications for Quenched-and-Tempered Carbon-Steel Axles, Shafts and Other Forgings for Locomotives and Cars (A.S.T.M. Designation: A 19 – 27):[1]

Section 5.—An amendment of the existing revision[2] is proposed changing the word "maximum" in Paragraph (*b*) to read "minimum," the paragraph as revised reading as follows:

> (*b*) In the case of boring, the diameter of the hole, unless otherwise specified, shall be at least 20 per cent of the minimum outside diameter of the forging, exclusive of collars and flanges.

Proposed Revision of Standard Specifications for Quenched-and-Tempered Alloy-Steel Axles, Shafts and Other Forgings for Locomotives and Cars (A.S.T.M. Designation: A 63 – 27):[1]

Section 5.—Make the same change in this section as recommended in Section 5 of Specifications A 19 – 27 above.

Editorial Revision of Standard Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A.S.T.M. Designation: A 83 – 34):[3]

Table III.—Change the footnote to this table to read as follows by the addition of the italicized words and the omission of the word in brackets:

> The gaging tolerances given apply only to tubes as rolled or drawn and before swaging, [and] expanding, *polishing, or other fabricating operations.*

Proposed Revision of Standard Specifications for Commercial Quality Hot-Rolled Bar Steels (A.S.T.M. Designation: A 107 – 33):[4]

Amendments of existing tentative revisions[5] of these specifications are proposed. The complete revisions follow:

Section 4.—Change to read as follows by the addition of the italicized words:

> 4. The steel shall conform to the requirements as to chemical composition specified in Tables I *and II* for the respective grades.

Section 5 (*a*).—Change from its present form: namely,

> 5. (*a*) For bessemer steel a carbon determination shall be made of each melt; and determinations for manganese, phosphorus and sulfur, representing the average of the melts made in each twelve-hour period.

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[1] 1933 Book of A.S.T.M. Standards, Part I, pp. 180, 187.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1376 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 1502.

[3] 1934 Supplement to Book of A.S.T.M. Standards, p. 26.

[4] 1933 Book of A.S.T.M. Standards, Part I, p. 93.

[5] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1381 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 1507.

to read as follows:

5. (*a*) For bessemer steel an analysis of each melt shall be made for carbon and manganese; and determinations for phosphorus representing the average of melts made during each 8-hr. turn. For bessemer grade 15 (welding steel), free-cutting steels and resulfurized nut stock the sulfur shall be determined for each melt.

TABLE I.—TYPES, GRADE DESIGNATIONS AND CHEMICAL COMPOSITIONS.

Grade Designations	Carbon, per cent	Manganese, per cent	Phosphorus, per cent	Sulfur, per cent
OPEN-HEARTH GRADES				
1	0.05 to 0.10	0.30 to 0.60	0.04 max.	0.05 max.
2	0.10 to 0.15	0.30 to 0.60	0.04 max.	0.05 max.
3	0.15 to 0.20	0.30 to 0.60	0.04 max.	0.05 max.
4	0.15 to 0.20	0.70 to 1.00	0.04 max.	0.05 max.
5	0.20 to 0.25	0.30 to 0.60	0.04 max.	0.05 max.
6	0.25 to 0.35	0.60 to 0.90	0.04 max.	0.05 max.
7	0.30 to 0.40	0.60 to 0.90	0.04 max.	0.05 max.
8	0.35 to 0.45	0.60 to 0.90	0.04 max.	0.05 max.
9	0.40 to 0.50	0.60 to 0.90	0.04 max.	0.05 max.
10	0.45 to 0.55	0.60 to 0.90	0.04 max.	0.05 max.
11	0.50 to 0.60	0.60 to 0.90	0.04 max.	0.05 max.
12	0.60 to 0.75	0.60 to 0.90	0.04 max.	0.05 max.
13	0.75 to 0.90	0.60 to 0.90	0.04 max.	0.05 max.
14	0.90 to 1.05	0.25 to 0.50	0.04 max.	0.05 max.
BESSEMER GRADES				
15	0.12 max.	0.60 max.	0.11 max.	0.08 max.
16	0.15 max.	0.70 max.	0.11 max.	....
17	0.15 to 0.25	0.90 max.	0.11 max.	....
18	0.25 to 0.35	0.90 max.	0.11 max.	....
19	0.35 to 0.50	0.90 max.	0.11 max.	....
BESSEMER FREE-CUTTING STEELS				
20	0.08 to 0.16	0.60 to 0.90	0.09 to 0.13	0.10 to 0.20
21	0.08 to 0.16	0.60 to 0.90	0.09 to 0.13	0.20 to 0.30
OPEN-HEARTH FREE-CUTTING STEELS				
22	0.15 to 0.25	0.60 to 0.90	0.06 max.	0.075 to 0.15
23	0.10 to 0.20	1.00 to 1.30	0.04 max.	0.075 to 0.15
24	0.10 to 0.20	1.30 to 1.60	0.04 max.	0.075 to 0.15
25	0.30 to 0.40	1.35 to 1.65	0.04 max.	0.075 to 0.15
BESSEMER RESULFURIZED NUT STOCK				
26	0.08 to 0.16	0.50 to 1.00	0.11 max.	0.075 to 0.15
OPEN-HEARTH RESULFURIZED NUT STOCK				
27	0.15 to 0.25	0.50 to 1.00	0.06 max.	0.075 to 0.15

Section 6 (a).—Change this section to read as follows by the addition of the italicized words and the omission of those in brackets:

6. (*a*).—Analyses may be made by the purchaser from finished bars representing each melt of open-hearth steel, and each melt, or lot of bars, of bessemer steel. The average chemical composition thus determined shall not vary from the limits specified more than *the amounts shown in Table II* [0.03 per cent over or 0.02 per cent under in carbon; 0.03 per cent over or 0.02 per cent under in manganese; 0.005 per cent over in phosphorus; and 0.005 per cent over in sulfur.]

Table I.—Change the table of chemical compositions from its present form to read as shown in the accompanying Table I.

New Table II.—Add the accompanying Table II as a new Table II, renumbering the present Table II as Table III.

TABLE II.—VARIATIONS FROM LIMITS SPECIFIED IN TABLE I, PERMITTED ON CHECK ANALYSIS.

ELEMENTS CONSIDERED		UNDER MINIMUM LIMIT, PER CENT	OVER MAXIMUM LIMIT, PER CENT
Carbon	max. limits up to 0.80 per cent, incl.	0.02	0.03
	max. limits over 0.80 per cent	0.03	0.04
Manganese	max. limits up to 1.00 per cent, incl.	0.02	0.03
	max. limits over 1.00 per cent	0.03	0.05
Phosphorus	when max. only is specified	....	0.005
Sulfur	except free-cutting and nut stock grades	....	0.005
	free-cutting and nut stock grades	0.01	.....

Present Table II.—Change the tabulated requirements for "Flats, Square-Edge and Round-Edge" in the present Table II, to be renumbered Table III, by deleting the column for flats $\frac{3}{16}$ in. in thickness or under, and by changing the heading over the next column from "Over $\frac{3}{16}$ to $\frac{1}{2}$, incl." to read "$\frac{1}{4}$ to $\frac{1}{2}$, incl."

Proposed Revision of Standard Specifications for Commercial Cold-Finished Bar Steels and Cold-Finished Shafting (A.S.T.M. Designation: A 108 – 33):[1]

Amendments of existing tentative revisions[2] of these specifications are proposed. The complete revisions follow:

Section 1 (a).—Change this section to read as follows by the addition of the italicized words and the omission of those in brackets:

1. (*a*) These specifications cover commercial cold-finished bar steels of grades considered to be in common use, including cold-finished [bessemer screw stock and cold-finished open-hearth screw stock] *free-cutting steels*, also cold-finished shafting and commercial key stock.

Section 2 (c).—Change this section to read as follows by the addition of the italicized words and the omission of those in brackets:

(*c*) The [steel in bessemer and open-hearth screw stock] *free-cutting steels* shall be [free-cutting and] suitable for high-speed screw machine work, leaving a smooth finish after machining under proper conditions.

Section 6 (a).—Change this section to read as follows by the addition of the italicized words and the omission of those in brackets:

6. (*a*) Analyses may be made by the purchaser from finished bars representing each melt of open-hearth steel, and each melt, or lot of ten tons, of bessemer steel. *The average of all the separate determinations made shall conform to the limits specified. The composition of individual samples may vary from that specified to the extent permitted*

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[1] 1933 Book of A.S.T.M. Standards, Part I, p. 89.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1382 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 1508.

in Table II. [The chemical composition thus determined shall conform to the requirements in Table I, with the permissible variations in ranges and in maximum limits specified in Table II.]

Table I.—Change the table of compositions from its present form to read as shown in the accompanying Table III.

TABLE III.—TYPES, GRADE DESIGNATIONS AND CHEMICAL COMPOSITIONS.

Grade Designations	Carbon, per cent	Manganese, per cent	Phosphorus, per cent	Sulfur, per cent
OPEN-HEARTH GRADES				
1	0.05 to 0.15	0.30 to 0.60	0.045 max.	0.055 max.
2	0.10 to 0.20	0.30 to 0.60	0.045 max.	0.055 max.
3	0.15 to 0.25	0.30 to 0.60	0.045 max.	0.055 max.
4	0.15 to 0.25	0.70 to 1.00	0.045 max.	0.055 max.
5	0.20 to 0.30	0.30 to 0.60	0.045 max.	0.055 max.
6	0.25 to 0.35	0.60 to 0.90	0.045 max.	0.055 max.
7	0.30 to 0.40	0.60 to 0.90	0.045 max.	0.055 max.
8	0.35 to 0.45	0.60 to 0.90	0.045 max.	0.055 max.
9	0.40 to 0.50	0.60 to 0.90	0.045 max.	0.055 max.
10	0.45 to 0.55	0.60 to 0.90	0.045 max.	0.055 max.
BESSEMER GRADES				
11	0.15 max.	0.60 max.	0.11 max.	....
BESSEMER FREE-CUTTING STEELS				
12	0.08 to 0.16	0.60 to 0.90	0.09 to 0.13	0.10 to 0.20
13	0.08 to 0.16	0.60 to 0.90	0.09 to 0.13	0.20 to 0.30
OPEN-HEARTH FREE-CUTTING STEELS				
14	0.15 to 0.25	0.60 to 0.90	0.06 max.	0.075 to 0.15
15	0.10 to 0.20	1.00 to 1.30	0.045 max.	0.075 to 0.15
16	0.10 to 0.20	1.30 to 1.60	0.045 max.	0.075 to 0.15
17	0.30 to 0.40	1.35 to 1.65	0.045 max.	0.075 to 0.15

Table II.—Change this table from its present form to read as shown in the accompanying Table IV:

TABLE IV.—VARIATIONS FROM LIMITS SPECIFIED IN TABLE I, PERMITTED ON CHECK ANALYSES OF INDIVIDUAL SAMPLES.

ELEMENTS CONSIDERED		UNDER MINIMUM LIMIT, PER CENT	OVER MAXIMUM LIMIT, PER CENT
Carbon[a]	max. limits up to 0.25 per cent, incl	0.02	0.03
	max. limits over 0.25 to 0.60 per cent, incl	0.03	0.04
Manganese	max. limits up to 1.00 per cent, incl	0.05	0.05
	max. limits over 1.00 per cent	0.05	0.10
Phosphorus, when max. only is specified		....	0.005
Sulfur	grades other than free-cutting	....	0.005
	free-cutting grades	0.01	.....

[a] Except that the carbon in any one melt or lot of bars may not vary both above and below the range specified.

FINAL REPORT ON EFFECT OF SULFUR IN STEEL

REPORT OF JOINT COMMITTEE ON INVESTIGATION OF THE EFFECT OF PHOSPHORUS AND SULFUR IN STEEL

The work of the Joint Committee on Investigation of the Effect of Phosphorus and Sulfur in Steel has been confined largely to the study of sulfur in steel. Of the five investigations on which reports have been issued, one dealt with phosphorus, the others with sulfur. Generalizations based on the committee's work completed to date must be limited to sulfur. Of the four investigations of sulfur in steel, three have dealt with steel in which the sulfur was "residual," that is, present throughout the entire melting operation, and one, with the effects of "added sulfur." Throughout the work all correlation between physical properties and chemical composition was based upon the results of analysis of the finished piece and not on ladel or heat analysis.

Types of Steel:

Residual Sulfur.—Three types of steels containing residual sulfur were studied: (1) Rivet steel in fourteen heats ranging in sulfur from 0.03 to 0.18 per cent, carbon 0.09 to 0.15 per cent, and manganese 0.35 to 0.64 per cent; (2) structural steel (plate) in six heats ranging in sulfur from 0.033 to 0.078 per cent, carbon 0.19 to 0.25 per cent, manganese 0.41 to 0.48 per cent; and (3) forging steels (1, 2 and 8-in. rounds) in eight heats ranging from 0.03 to 0.10 per cent sulfur, carbon 0.45 to 0.58 per cent and manganese 0.47 to 0.75 per cent. All were prepared under careful supervision on a full-size scale of operation and in some cases the excess ingots, over those designated by the committee for its work, entered into the regular production of the mill. It was distinctly recognized by the committee, however, that all steels designated herein as "forging steels" were of the plain carbon grade such as are intended for general use and not for forgings of the quality required for automobile and ordnance service.

Added Sulfur.—The investigation of the effects of "added sulfur" was carried out by adding sulfur in the form of FeS in increasing amounts to individual ingots of each of three heats considered to be representative of (1) structural steel, carbon 0.20 per cent, manganese 0.50 per cent, sulfur ranging from 0.033 to 0.136 per cent; (2) forging steel, carbon 0.37 per cent, manganese 0.60 per cent, sulfur ranging from 0.026 to 0.152 per cent;

and (3) a high-carbon steel of rail composition, carbon 0.77 per cent, manganese 0.62 per cent, and sulfur ranging from 0.033 to 0.153 per cent. These steels were rolled into 1-in. rounds and 1 by 4½-in. strips, not into rails or other commercial forms.

Cast Steel:

No tests have been carried out on cast steel. This part of the initial program was omitted because it was found to have no commercial interest for the steel casting industry. Its representatives on the Joint Committee explained the prevailing belief of steel foundrymen that sulfur exceeding 0.06 per cent is likely to cause shrinkage cracks or hot tears in steel castings so designed as to develop susceptibility to defects related to excessive red shortness.

Tests:

Visual observations on the behavior of the various steels while they were being mechanically worked indicated that the ability of the steels to be deformed at elevated temperatures was not seriously affected by the higher sulfur content, that is, to a degree such as to render their mechanical working commercially impracticable. The mechanical properties of the finished stock were determined at room temperature, these being the properties on which specifications are based and on which service behavior largely depends. In addition, in the case of the low-carbon steel (rivet stock) finished rivets were also tested while hot.

Conclusions:

On the basis of the test data, the committee announced its general conclusion (1926)[1] that sulfur in rivet steel up to and including 0.06 per cent is not detrimental. For material in each of the three conditions, natural, annealed and quenched, an increase in sulfur from 0.063 to 0.18 per cent was accompanied by a decrease in ductility (elongation and reduction of area) perpendicular to direction of rolling and also in the impact resistance for material tested both parallel and perpendicular to the direction of rolling. However, for the same range in sulfur content for material in the natural, annealed and quenched conditions, no systematic relation with sulfur was found for tensile strength, proportional limit and yield point for material tested both parallel and perpendicular to direction of rolling; percentages of elongation and reduction of area for material tested parallel to direction of rolling; shearing strength; hardness; torsional properties; endurance limit; cold bend tests of bars; cold bending, hot flattening, and hot and cold upsetting tests of rivets.

Concerning structural steel (plate), the committee concluded (1927)[1] that sulfur up to 0.077 per cent, the maximum used in the tests, is not detrimental. No systematic relation was noted between sulfur content and the tensile, shear and bend properties of the plate in the natural, normalized, annealed and quenched conditions. All the values for impact resistance showed such wide variation in individual results that no conclusions regarding any deleterious effect of sulfur with respect to this property could be drawn.

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[1] See appended references.

In considering the effect of sulfur on the type of forging steel used, no permissible maximum content for sulfur was expressed. The committee, however, decided (1934)[1] that the evidence, though less clear-cut than might be desired, showed no systematic relation between increasing sulfur contents and the physical properties studied, and pointed to the conclusion that the physical effects of the sulfur were of such low magnitude they were masked by other more potent variables—for example, variations in carbon and manganese. As in the preceding case, the values for impact resistance were so variable that no conclusion as to the relationship to sulfur content was possible.

No conclusions were drawn by the committee concerning the effect of added sulfur in the three types of steel studied when the results of the tests were reported in 1923.[1] Considering the data there presented it is clear that results obtained are consistent with the conclusions regarding steels with corresponding content of residual sulfur, expressed in the preceding paragraphs of this report.

General Application of Conclusions:

The committee's conclusions have been based primarily on the test data obtained in static tests supplemented, in the case of the rivet steels, by endurance tests, and in drawing the conclusions consideration has been given to the various conditions in which the steel may exist with respect to heat treatment. The data obtained in the impact tests were so variable that no conclusions concerning a possible relationship between the results of these tests and sulfur content or other composition variables have seemed to be warranted. In general, the committee believes that, on the basis of its previous conclusions, a sulfur content of 0.07 per cent is permissible in a finished product of wrought plain carbon steels, the carbon content of which does not exceed 0.55 per cent and manganese content, 0.70 per cent, when used under conditions in which the transverse properties are not of controlling importance. The carbon and manganese contents named are the highest covered by the committee's tests; consequently the conclusions are restricted to the percentages stated, without prejudice to higher amounts of carbon or manganese. In the case of rivet stock, however, the previous recommendations of a permissible sulfur content of 0.06 per cent should stand because of the possible pickup of sulfur in the heating of rivets incidental to fabrication operations. Since no data on cast steel are available as a result of tests by the committee, no conclusions are drawn by the committee as to the possible applicability of the available data to cast steels.

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[1] See appended references.

A list of the published reports of the committee dealing with the effect of sulfur is appended.

Respectfully submitted on behalf of the committee,

H. S. RAWDON,
Chairman.

C. L. WARWICK,
Secretary.

APPENDIX

LIST OF JOINT COMMITTEE REPORTS ON EFFECT OF SULFUR

On Effect of Residual Sulfur

Rivet Steel

Report on Effect of Sulfur on Rivet Steel, *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 94 (1922).

Report on Effect of Sulfur on Endurance Properties of Rivet Steel, *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 96 (1924).

Report on Metallographic Investigation of Effect of Sulfur on Rivet Steel, *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 108 (1924).

Report on Effect of Sulfur on Rivet Steel, *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 114 (1926).

Structural Steel

Report on Effect of Sulfur on Structural Steel, *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 185 (1924).

Report on Effect of Sulfur on Plate Material, *Proceedings*, Am. Soc. Testing Mats., Vol. 27, Part I, p. 135 (1927).

Forging Steel

Report on Effect of Sulfur on Forging Steel, *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, p. 87 (1934).

On Effect of Added Sulfur

Report on Effect of "Added Sulfur" on Structural, Forging and Rail Steels, *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part I, p. 105 (1923).

REPORT OF SECTIONAL COMMITTEE

ON

STANDARDIZATION OF DIMENSIONS AND MATERIAL OF WROUGHT IRON AND WROUGHT STEEL PIPE AND TUBING

A.S.A. Project: B36

The approval by the American Standards Association in November, 1935, of the American Tentative Standard for Wrought Iron and Wrought Steel Pipe culminated eight years of work by the Sectional Committee on Standardization of Dimensions and Material of Wrought Iron and Wrought Steel Pipe and Tubing. This committee has been functioning under the procedure of the American Standards Association with the American Society of Mechanical Engineers and A.S.T.M. as joint sponsors.

For material requirements, the tentative standard contains parts of, and refers specifically to, ten A.S.T.M. and one A.P.I. pipe specifications. It recommends that material be ordered and made in accordance with these specifications or subsequent revisions thereof. All of the A.S.T.M. specifications have been approved as American standards or American tentative standards. In order to keep them in step with revisions effected in the corresponding A.S.T.M. specifications, revisions or extensions which may be made from time to time in A.S.T.M. specifications will be referred to the sectional committee for letter ballot approval prior to inclusion in the pipe standard.

The sectional committee reports the completion of the final standard, A.S.A. B 36.10-1935, as fulfilling the purpose for which the committee was organized; that is, "to coordinate and standardize with a view to reducing unnecessary duplication, the design, dimensions, and material requirements of pipe." The standard has been published by the American Society of Mechanical Engineers and copies may be secured either from that organization or from the American Society for Testing Materials.

Respectfully submitted on behalf of the sectional committee,

H. H. Morgan,
Chairman.

Sabin Crocker,
Secretary.

REPORT OF COMMITTEE A-2
ON
WROUGHT IRON

Committee A-2 on Wrought Iron has held one meeting this year, in Pittsburgh, Pa., on March 3, 1936. A second meeting will be held prior to the presentation of this report to the Society when the report will be reviewed and other matters considered.

It is with regret that the committee announces the death of Mr. William Downs of the Burden Iron Co. An appropriate resolution was sent to the Burden Iron Co. and to the family of Mr. Downs. This resolution appears elsewhere in this report.

The resignations during the year of Mr. H. E. Smith, Materials Engineer, and of the Old Dominion Iron & Steel Co., Thomas S. Wheelwright, President, were accepted with regret at the March meeting.

RECOMMENDATIONS AFFECTING STANDARDS

Recommendations of the committee affecting standards are presented first in summarized form, together with an analysis of the letter ballot on each item. They are then further referred to under subcommittee activities, being grouped for convenience in the order of the respective subcommittees responsible for them.

I. Proposed Tentative Standard.—The committee recommends that the proposed Tentative Specifications for Single and Double Refined Wrought-Iron Bars, prepared by Subcommittee II, as appended hereto,[1] be accepted for publication as tentative.

II. Revision of Tentative Standard.—The committee recommends that the Tentative Specifications for Wrought-Iron Rivets and Rivet Rounds (A 152 – 35 T) be revised in accordance with the changes proposed by Subcommittee III, and the specifications as revised continued as tentative.

III. Revision of Standards.—The committee recommends that revisions of the following specifications be immediately adopted as standard. The committee accordingly asks for the necessary nine-tenths vote at the annual meeting in order that these revisions may be referred to letter ballot of the Society for immediate adoption:

Standard Specifications for:

Refined Wrought-Iron Bars (A 41 – 30), revised as proposed by Subcommittee II,

Staybolt, Engine-Bolt and Other High-Grade Wrought-Iron Bars (A 84 – 33), revised as appended hereto[2] as proposed by Subcommittee III, and

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[1] See p. 648.

[2] See 1936 Book of A.S.T.M. Standards, Part I, p. 437.

Hollow Rolled Staybolt Iron (A 86 – 35), revised as appended hereto[1] as proposed by Subcommittee III.

IV. Adoption of Tentative Standards as Standard.—The committee recommends that the following two tentative specifications be approved for reference to letter ballot of the Society for adoption as standard:

Tentative Specifications for:

Uncoated Wrought-Iron Sheets (A 162 – 35 T), proposed by Subcommittee IV, and

Zinc-Coated (Galvanized) Wrought-Iron Sheets (A 163 – 35 T), proposed by Subcommittee IV.

V. Adoption of Tentative Revisions of Standards as Standard.—The committee recommends that the tentative revisions proposed in 1935 in the following five standard specifications be submitted to the Society for adoption as standard:

Standard Specifications for:

Wrought-Iron Rolled or Forged Blooms and Forgings for Locomotives and Cars (A 73 – 30), proposed by Subcommittee VI;

Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 – 34), proposed by Subcommittee I;

Staybolt, Engine-Bolt and Other High-Grade Wrought-Iron Bars (A 84 – 33), proposed by Subcommittee III;

Refined Wrought-Iron Bars (A 41 – 30), proposed by Subcommittee II;

Common Iron Bars (A 85 – 27), proposed by Subcommittee II;

Hollow Rolled Staybolt Iron (A 86 – 35), proposed by Subcommittee III.

VI. Withdrawal of Standard.—The committee recommends the withdrawal of the Standard Specifications for Wrought-Iron Plates (A 42 – 30) since these are replaced by the existing Tentative Specifications for Wrought-Iron Plates (A 42 – 35 T).

The recommendations appearing in this report have been submitted to letter ballot of the committee, which consists of 54 members; 46 members returned their ballots, with the results shown in Table I.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Tubes and Pipe (G. H. Woodroffe, chairman).—Subcommittee I is recommending the adoption as standard of the tentative revisions[2] proposed in 1935 in the Standard Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 – 34).[3] The subcommittee also concurs in the recommendation of Committee A-1 on Steel that the following editorial change be made immediately in these specifications, which are under the joint jurisdiction of Committee A-1 and Committee A-2:

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[1] See 1936 Book of A.S.T.M. Standards, Part I, p. 441.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1384 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 1510.

[3] 1934 Supplement to Book of A.S.T.M. Standards, p. 26.

Table III.—Change the footnote to this table to read as follows by the addition of the italicized words and the omission of the word in brackets:

> The gaging tolerances given apply only to tubes as rolled or drawn and before swaging, [and] expanding, *polishing, or other fabricating operations.*

Subcommittee II on Merchant Bar Iron (J. B. Young, chairman).—This subcommittee is presenting for publication as tentative proposed Tentative Specifications for Single and Double Refined Wrought-Iron Bars, appended hereto.[1] These specifications cover a grade of high quality single refined and a grade of high quality double refined iron. These specifications were prepared in order to have available a standard covering high-grade wrought-iron bars which do not permit the use of admixtures of purchased iron scrap or steel. The specifications are in general agreement with the Specifications for Refined Wrought Iron Bars (M–302–34) of the Association of American Railroads but differ somewhat in wording and arrangement.

TABLE I.—ANALYSIS OF LETTER BALLOT VOTE.

Items	Affirmative	Negative	Ballots Marked "Not Voting"
I. PROPOSED TENTATIVE STANDARD			
Specifications for Single and Double Refined Wrought-Iron Bars	42	2	2
II. REVISION OF TENTATIVE STANDARD			
Specifications for Wrought-Iron Rivets and Rivet Rounds (A 152 – 35 T)	42	0	4
III. REVISION OF STANDARDS			
Specifications for Refined Wrought-Iron Bars (A 41 – 30), immediate adoption	44	0	2
Specifications for Staybolt, Engine-Bolt and Other High-Grade Wrought-Iron Bars (A 84 – 33), immediate adoption	45	0	1
Specifications for Hollow Rolled Staybolt Iron (A 86 – 35), immediate adoption	43	0	3
IV. ADOPTION OF TENTATIVE STANDARDS AS STANDARD			
Specifications for Uncoated Wrought-Iron Sheets (A 162 – 35 T)	35	0	11
Specifications for Zinc-Coated (Galvanized) Wrought-Iron Sheets (A 163 – 35 T)	34	0	12
V. ADOPTION AS STANDARD OF TENTATIVE REVISIONS OF STANDARDS			
Specifications for Wrought-Iron Rolled or Forged Blooms and Forgings for Locomotives and Cars (A 73 – 30)	37	0	9
Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 – 34)	38	0	8
Specifications for Staybolt, Engine-Bolt and Other High-Grade Wrought-Iron Bars (A 84 – 33)	45	0	1
Specifications for Refined Wrought-Iron Bars (A 41 – 30)	44	0	2
Specifications for Common Iron Bars (A 85 – 27)	41	0	5
Specifications for Hollow Rolled Staybolt Iron (A 86 – 35)	43	0	3
VI. WITHDRAWAL OF STANDARD			
Specifications for Wrought-Iron Plates (A 42 – 30)	38	0	5

The subcommittee is also recommending the following revisions for immediate adoption in the Standard Specifications for Refined Wrought-Iron Bars (A 41 – 30):[2]

Title.—Change to read as follows by the omission of the word in brackets:

> Standard Specifications for Refined [Wrought] Iron Bars

Section 1.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

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[1] See p. 648.

[2] 1933 Book of A.S.T.M. Standards, Part I, p. 433.

1. The bars shall be made from *a mixture of new* wrought iron, and [may consist either of all new iron or a mixture of new iron and] scrap, but shall be free from any admixture of steel.

New Section.—Following Section 1, add a center heading to read "Chemical Composition and Tests" and add the following as a new Section 2, renumbering the subsequent sections accordingly:

2. The iron shall conform to the following requirement as to chemical composition:

Manganese, max., per cent.................................. 0.15

The subcommittee also recommends the adoption as standard of the tentative revisions[1] proposed in 1935 in the Standard Specifications for Refined Wrought-Iron Bars (A 41 – 30)[2] and for Common Iron Bars (A 85 – 27).[2]

Subcommittee III on Staybolt and Engine-Bolt Iron (E. J. Edwards, chairman).—The subcommittee is recommending for immediate adoption revisions of the Standard Specifications for Staybolt, Engine-Bolt and Other High-Grade Wrought-Iron Bars (A 84 – 33),[3] and for Hollow Rolled Staybolt Iron (A 86 – 35).[4] These revisions have been incorporated in the completely modified specifications appended hereto[5] which are entitled "Specifications for Staybolt Wrought Iron, Solid" and "Specifications for Staybolt Wrought Iron, Hollow Rolled," respectively.

Under the proposed revisions, Standard Specifications A 84 will cover only wrought iron for solid staybolts which corresponds to Grade A material of the present standard. The revised Specifications A 84 will not include bars of Grades B and B_1 which will be covered by the proposed Tentative Specifications for Single and Double Refined Wrought-Iron Bars, being proposed by Subcommittee II. The elimination of these two grades from Specifications A 84 is contingent upon approval by Committee A-2 and the Society of the specifications for single and double refined wrought-iron bars.

The revised specifications are in general agreement with Specifications for Hollow Rolled Staybolt Iron (M-304–34) and for Solid Staybolt Iron (M-305–34) of the Association of American Railroads, with certain modifications which the committee believes are desirable.

The subcommittee also recommends the adoption as standard of the tentative revisions[6] proposed in 1935 in both of these specifications. These revisions have been incorporated in the specifications appended.

The subcommittee also recommends that the Tentative Specifications for Wrought-Iron Rivets and Rivet Rounds (A 152 – 35 T)[7] be revised as follows and continued as tentative:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1388 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 1514.

[2] 1933 Book of A.S.T.M. Standards, Part I, pp. 429, 433.

[3] *Ibid.*, p. 437.

[4] 1935 Supplement to Book of A.S.T.M. Standards, p. 19.

[5] See 1936 Book of A.S.T.M. Standards, Part I, pp. 437, 441.

[6] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, pp. 1388, 1389 (1935); also 1935 Book of A.S.T.M. Tentative Standards, pp. 1514, 1515.

[7] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 696 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 226.

Section 2.—Change the manganese requirement from "0.05 per cent, max." to read "0.06 per cent, max."

Section 4.—In the table of minimum requirements as to tensile properties, change the elongation requirement to read as follows by the addition of the italicized material and the omission of that in brackets:

Elongation in 8 in., per cent	*rounds 1/4 to 7/16 in., incl., in diam*	*22*
	rounds [½] *7/16* to ¾ in., incl., in diam	24
	rounds over ¾ to 2 in., incl., in diam	28

Omit Paragraph (*b*) which reads as follows, relettering Paragraph (*c*) as (*b*):

(*b*) Rounds under ½ in. in diameter will not be required to meet an elongation requirement.

Subcommittee IV on Plates, Shapes and Sheets (James Aston, chairman).—Subcommittee IV is recommending for adoption as standard the Tentative Specifications for Uncoated Wrought-Iron Sheets (A 162 – 35 T),[1] and for Zinc-Coated (Galvanized) Wrought-Iron Sheets (A 163 – 35 T).[1] The subcommittee also recommends the withdrawal of the Standard Specifications for Wrought-Iron Plates (A 42 – 30)[2] which have been replaced by the existing Tentative Specifications for Wrought-Iron Plates (A 42 – 35 T).[3] Certain revisions in the tentative specifications are under consideration.[4] These changes which were not completed in time to be included in this report of the committee are intended to clarify the present specifications and do not change them in any fundamental particular.

Subcommittee VI on Wrought-Iron Blooms and Forgings.—The subcommittee is recommending the adoption as standard of the revisions[5] proposed in 1935 in the Standard Specifications for Wrought-Iron Rolled or Forged Blooms and Forgings for Locomotives and Cars (A 73 – 30).[6]

RESOLUTION ON DEATH OF WILLIAM DOWNS

Adopted by Committee A-2 on Wrought Iron

WHEREAS it has pleased God in His wisdom to call to Him our friend William Downs who for many years has been a member of this Committee and in that time made no enemies but endeared himself to us all through his genial personality, kindliness and cheerfulness and,

WHEREAS the members of the Committee wish to officially express their sorrow and regret at his death, therefore

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, pp. 701, 704 (1935); also 1935 Book of A.S.T.M. Tentative Standards, pp. 231, 234.

[2] 1933 Book of A.S.T.M. Standards, Part I, p. 459.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 690 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 220.

[4] Subsequent to the annual meeting Committee A-2 presented to the Society through Committee E-10 on Standards revisions in the Tentative Specifications for Wrought-Iron Plates (A 42 – 35 T), see Editorial Note, p. 98.—ED.

[5] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1388 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 1514.

[6] 1933 Book of A.S.T.M. Standards, Part I, p. 446.

BE IT RESOLVED that the members of Committee A-2 on Wrought Iron of the American Society for Testing Materials in meeting assembled the third day of March, 1936, feel keenly the loss of our friend and extend our deepest sympathy to those most closely associated with him by family or business ties, and

BE IT FURTHER RESOLVED that a copy of this resolution be sent Mrs. Downs and to The Burden Iron Company.

The election of officers for the ensuing term of two years resulted in the selection of J. B. Young, chairman; James Aston, vice-chairman; and G. H. Woodroffe, secretary.

This report has been submitted to letter ballot of the committee which consists of 54 members; 47 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

H. W. FAUS,
Chairman.

G. H. WOODROFFE,
Secretary.

EDITORIAL NOTE

Subsequent to the annual meeting Committee A-2 on Wrought Iron presented to the Society on August 26, 1936, through Committee E-10 on Standards proposed revisions of the Tentative Specifications for Wrought-Iron Plates (A 42 – 35 T). These revisions were accepted by Committee E-10 and the tentative specifications in their revised form appear on p. 652.

REPORT OF COMMITTEE A-3
ON
CAST IRON

Since the 1935 annual meeting of the Society, Committee A-3 on Cast Iron held two meeetings, one at Pittsburgh, Pa., on March 2, 1936, and the other at Detroit, Mich., on May 5, 1936. A third meeting will be held prior to the presentation of this report to the Society, at which time the report will be reviewed and other matters considered.

The present membership of the committee is 94, of which 39 are classified as producers, 22 as consumers, and 33 as general interest members.

RECOMMENDATIONS AFFECTING STANDARDS

I. *Proposed Tentative Standard:*

The committee recommends that the proposed Tentative Specifications for Lightweight and Thin-Sectioned Gray-Iron Castings be accepted for publication as tentative as appended hereto.[1]

II. *Adoption of Tentative Standard as Standard:*

The committee recommends that the Tentative Specifications for Gray-Iron Castings (A 48 – 35 T) with certain editorial changes as proposed by Subcommittee VI on General Castings later in this report be approved for reference to letter ballot of the Society for adoption as standard.

III. *Withdrawal of Standard:*

The withdrawal of the Standard Specifications for Chilled Cast-Iron Wheels (A 46 – 24)[2] is recommended. These specifications have been superseded by the existing Tentative Specifications for Chilled-Tread Cast-Iron Wheels (A 46 – 30 T).

The recommendations in this report have been submitted to letter ballot of the committee, which consists of 94 members; the results being as follows:

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[1] See p. 663.

[2] 1933 Book of A.S.T.M. Standards, Part I, p. 471.

Items	Affirm-ative	Neg-ative	Ballots Marked "Not Voting"
I. PROPOSED TENTATIVE STANDARD Specifications for Lightweight and Thin-Sectioned Gray-Iron Castings..........................	52	0	11
II. ADOPTION OF TENTATIVE STANDARD AS STANDARD Specifications for Gray-Iron Castings (A 48 – 35 T), editorial changes..........................	55	1	7
III. WITHDRAWAL OF STANDARD Specifications for Chilled Cast-Iron Wheels (A 46 – 24)..........................	46	1	5

ACTIVITIES OF SUBCOMMITTEES

Subcommittee IV on Car Wheels (F. K. Vial, chairman).—Subcommittee IV has been engaged in the revision of the Tentative Specifications for Chilled-Tread Cast-Iron Wheels (A 46 – 30 T). It is expected that the revised specifications will be completed for presentation to the Society during the year. In the meantime the subcommittee has recommended that the Standard Specifications for Chilled Cast-Iron Wheels (A 46 – 24) be withdrawn because they are obsolete and are superseded by the tentative specifications.

Subcommittee V on Light Gray-Iron Castings (W. J. Grede, chairman).—This subcommittee has developed the proposed Tentative Specifications for Lightweight and Thin-Sectioned Gray-Iron Castings, appended hereto,[1] which have been approved in substance by letter ballot of the committee. These specifications were later subjected to editorial changes and will be presented for final approval of the committee at the June meeting.

Subcommittee VI on General Castings (J. W. Bolton, chairman).—The Tentative Specifications for Gray-Iron Castings (A 48 – 35 T)[2] are being recommended for adoption as standard with the following minor editorial changes proposed by this subcommittee:

Section 5.—Add to this section the following as a new Paragraph (*c*):

> (*c*) When the controlling section is very heavy in comparison to other sections of the casting, if maximum strength is sought in the controlling section, it is possible that chilled spots may be found in the light sections. In such cases it may be necessary to (*1*) use lower strength class for the controlling section or (*2*) modify the design t provide more section uniformity.

Section 7.—Change this section to read as follows by the addition o the italicized sentence:

> 7. Tension test specimens shall fit the holders of the testing machine in such way that the load shall be axial. The use of self-aligning shackles is recommende (Note 8). *After reaching a stress equivalent to 15,000 lb. per sq. in. the speed of th moving head of the testing machine shall not exceed ⅛ in. (0.125 in.) per min.*

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[1] See p. 663.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 713 (1935); also 1935 Book of A.S.T.M. Te tative Standards, p. 243.

Section 8.—Change from its present form: namely,

8. The transverse test shall be made on the bar as cast with central loading between supports. Corrections shall be made for sizes of bars as shown in Table I. Controlling dimensions shall be the diameter of the bar at the fracture. The rate of application of the load shall be such that fracture is produced in not less than 15 sec. for the 0.875-in. diameter bar, 20 sec. for the 1.2-in. diameter bar, and 40 sec. for the 2.0-in. diameter bar.

to read as follows:

8. (*a*) The transverse test shall be made on the bar as cast, or as skin machined (providing in the latter case that the diameter is not reduced below the minimum sizes given in Table I) with central loading between supports. Corrections shall be made for sizes of round bars as shown in Table I. In case of slightly elliptical bars (maximum and minimum diameters both within the tolerances given in Table I), loading shall be on the minimum diameter, and the correction factor shall be obtained as follows: Square the depth of the bar measured at the point of application of the original load, multiply by the width, and divide the product by the cube of the diameter of the standard or nominal size bar. A bar whose diameters (maximum and minimum) vary by more than 0.025 in. for the 0.875-in. diameter nominal size, or by more than 0.050 in. for the 1.2 and 2.0-in. diameter nominal sizes, respectively, shall be considered a slightly elliptical bar.

(*b*) In all cases, controlling dimensions shall be the diameter of the bar at fracture.

(*c*) The rate of application of the load shall be such that fracture is produced in not less than 15 sec. for the 0.875-in. diameter bar, 20 sec. for the 1.2-in. diameter bar, and 40 sec. for the 2.0-in. diameter bar.

Subcommittee VIII on Cast-Iron Culvert Pipe (E. F. Kelley, chairman).—Subcommittee VIII is engaged in the revision of the Tentative Specifications for Cast-Iron Culvert Pipe (A 142 – 35 T) and it is expected that the revisions will be completed for presentation to the Society during the year.

Subcommittee X on Nomenclature and Definitions (Robert Job, chairman).—This subcommittee has developed Proposed Definitions of Terms Relating to Cast Iron and these definitions have been published[1] as information. Modifications are now being made in the definitions and will be offered for approval of the committee at the June meeting.[2]

Subcommittee XI on Methods of Testing (R. S. MacPherran, chairman).—The subcommittee has secured test data which have been of value and assistance to Subcommittee VI in the development and improvement of the Tentative Specifications for Gray-Iron Castings (A 48 – 35 T).

The election of officers for the ensuing term of two years resulted in the election of W. H. Rother, chairman; A. L. Boegehold, vice-chairman; and H. C. Aufderhaar, secretary.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 80 (1935).

[2] Subsequent to the annual meeting Committee A-3 presented these definitions as tentative to the Society through Committee E-10 on Standards, see Editorial Note, p. 102.—ED.

This report has been submitted to letter ballot of the committee which consists of 94 members; 63 members returned their ballots, of whom 62 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

HYMAN BORNSTEIN,
Chairman.

E. K. SMITH,
Secretary.

EDITORIAL NOTE

Subsequent to the annual meeting Committee A-3 on Cast Iron presented to the Society on August 26, 1936, through Committee E-10 on Standards proposed Tentative Definitions of Terms Relating to Cast Iron. These definitions were accepted by Committee E-10 and appear on p. 667.

REPORT OF COMMITTEE A-5
ON
CORROSION OF IRON AND STEEL

Committee A-5 on Corrosion of Iron and Steel has held two meetings during the past year; one in June, 1935, during the annual meeting of the Society at Detroit, Mich., and the other in March, 1936, at the spring group meeting of A.S.T.M. committees held in Pittsburgh, Pa.

Since the last report, 4 new members have been elected and 12 resignations accepted; the committee membership now totals 117, of whom 52 are classified as producers, 46 as consumers, and 19 as general interest members.

RECOMMENDATIONS AFFECTING STANDARDS

Proposed Tentative Standards.—The committee recommends the proposed Tentative Method of Test for Uniformity of Coating by the Preece Test (Copper Sulfate Dip) on Zinc-Coated (Galvanized) Iron or Steel Wire, appended hereto,[1] for publication as tentative. The committee has considered it desirable to standardize the method for carrying out the Preece test, particularly for galvanized wire. It has reached this decision after careful study, believing that since the Preece test is very generally used in the industry an approved technique for its use on wire should be standardized and the limitations of the test carefully and plainly stated. In this method, the procedure for testing has been revised in accordance with recent thorough technical studies of the basic principles involved in the test.

This recommendation has been referred to letter ballot of the committee, which consists of 117 members; 86 members returned their ballots, of whom 74 have voted affirmatively, 1 negatively and 11 marked their ballots "not voting."

ACTIVITIES OF SUBCOMMITTEES

Subcommittee III on Inspection of Annapolis Tests (E. S. Taylerson, chairman).—Since the inspection on November 2, 1934, of the black sheets exposed at Annapolis, Md.,[2] the subcommittee has held two meetings at Annapolis. On April 26, 1935, three failures were observed: namely, C24, V4 and V10 (all copper-bearing pure iron). On November 4, 1935, twelve failures were recorded: namely, C3, C4, U5, U9, U10, U12, U14 and V6 (all copper-bearing pure iron), A11 and A15 (low-copper bessemer steel), X11 (low-copper pure iron), and Z418 (low-copper open-hearth steel). None of the No. 16 gage sheets have failed, all of the above failures being in the No. 22 gage material. The tests are being continued.

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[1] See p. 645.

[2] For detailed tabulations of failures observed in the tests at Annapolis, see Table I (Plate I) of the 1934 Report of Committee A-5, *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, p. 156 (1934); for additional failures reported in 1935, see *Proceedings*, Vol. 35, Part I, p. 83 (1935).

Subcommittee V on Total Immersion Tests (W. J. Jeffries, chairman).—The regular inspections of the immersion tests being carried out at Portsmouth, N. H., and Key West, Fla., have been made during the year and a summary of all failures in the No. 16 gage sheet steel specimens is given in the accompanying Tables I and II (Plates I and II).

No inspection of riveted test plates has been made this year since it has been decided to carry on the inspection of these plates (described in the 1932 report[1]) every other year rather than annually as in the past.

The 2 by 12-in. specimens of tubing immersed with the sheet steel specimens have been given the regular monthly inspection concurrently with the sheet specimens. General corrosion and pitting are reported to be uniform over all the specimens but the tests have not progressed to a point where conclusions may be drawn.

Subcommittee VI on Specifications for Metallic Coated Products (V. F. Hammel, chairman).—The subcommittee has held its customary meetings and reports the following action. A review of the general situation relating to the Standard Specifications for Zinc-Coated (Galvanized) Sheets (A 93 – 27) has indicated that it is not desirable to undertake a revision of these specifications at this time. The committee reports the expression of considerable interest in the Tentative Specifications for Electrodeposited Coatings of Zinc on Steel (A 164 – 35 T), for Electrodeposited Coatings of Cadmium on Steel (A 165 – 35 T) and for Electrodeposited Coatings of Nickel and Chromium on Steel (A 166 – 35 T) which were issued last year. It is planned to continue these specifications as tentative for another year to await the results of longer and more general usage of the specifications before they are considered for revision.

The committee is actively reviewing the Standard Specifications for Zinc-Coated (Galvanized) Iron or Steel Telephone and Telegraph Line Wire (A 111 – 33), for Zinc-Coated (Galvanized) Iron or Steel Farm-Field and Railroad Right-of-Way Wire Fencing (A 116 – 30) and for Zinc-Coated (Galvanized) Iron or Steel Wire Strand (Cable) (A 122 – 33) with a view to making such revisions as are desirable to bring these specifications up to date and in line with improvements in the manufacture of these materials. This work has not been carried to a point where definite recommendations can be made at this time.

Subcommittee VII on Methods of Testing (L. W. Hopkins, chairman).—Subcommittee VII has developed and presented to the main committee

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 105 (1932).

TABLE I.—REPORT ON TOTAL IMMERSION TESTS. SHEETS EXPOSED MA

No. 16 GAGE

Designation	Series	Description	Average Analysis, per cent						Number of Sheets in Test							
			Carbon	Manganese	Phosphorus	Sulfur	Silicon	Copper		Sept. 6, 1929, 920 Days	Oct. 7, 1929,[a] 951 Days	Nov. 7, 1929, 982 Days	June 6, 1930, 1193 Days	Sept. 6, 1930, 1285 Days	Jan. 8, 1931,[a] 1409 Days	Mar. 10, 1931, 1470 Days
Bessemer Steel	A	Non-Copper-Bearing	0.030	0.420	0.085	0.040	0.003	0.012	6							
Bessemer Steel, Youngstown Sheet and Tube Co	B	“ “ “	0.080	0.440	0.080	0.032	.	0.014	6		1					
Copper-Bearing Bessemer Steel	A	Copper-Bearing	0.060	0.360	0.091	0.066	0.005	0.254	6							
Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	“ “	0.078	0.340	0.091	0.036		0.287	6							
Open-Hearth Steel	A	Non-Copper-Bearing	0.058	0.359	0.022	0.049	0.005	0.109	6							
Open-Hearth Steel	A	“ “ “	0.280	0.500	0.027	0.038	0.010	0.034	6							
Low-Copper Open-Hearth Steel	A	“ “ “	0.110	0.360	0.008	0.029	trace	0.026	6			3			13	
Open-Hearth Steel, Alan Wood Steel Co	B	“ “ “	0.111	0.400	0.010	0.028	0.011	0.053	6							2
Open-Hearth Steel, Youngstown Sheet and Tube Co	B	“ “ “	0.047	0.389	0.040	0.027	0.007	0.033	6	418				417		
Open-Hearth Steel	A	Copper-Bearing	0.290	0.510	0.028	0.039	0.010	0.217	6							
Copper-Bearing Basic Open-Hearth Steel	A	“ “	0.069	0.371	0.010	0.026	0.004	0.248	6							
Copper-Bearing Steel, Newport Rolling Mill Co	B	“ “	0.087	0.330	0.009	0.019	0.008	0.239	6							
Copper-Bearing Open-Hearth Steel, Youngstown Sheet and Tube Co	B	“ “	0.075	0.390	0.070	0.073		0.257	6							
Low-Copper Pure Iron	A	Non-Copper-Bearing	0.020	0.027	0.005	0.033	0.003	0.078	6							
Low-Copper Pure Iron	A	“ “ “	0.019	0.025	0.004	0.027	0.003	0.028	6				24			
Low-Copper Pure Iron, American Rolling Mill Co	B	“ “ “	0.015	0.021	0.006	0.020	0.005	0.023	6		6				21	
Low-Copper Pure Iron, Inland Steel Co	B	“ “ “	0.028	0.060	0.009	0.028	0.006	0.030	6		13	11				
Copper-Bearing Pure Iron	A	Copper-Bearing	0.018	0.028	0.005	0.032	0.006	0.262	6							
Copper-Bearing Pure Iron, Allegheny Steel Co	B	“ “	0.014	0.075	0.006	0.028	0.007	0.250	6							
Copper-Bearing Pure Iron, Whitaker-Glessner Co	B	“ “	0.009	0.050	0.008	0.018		0.288	6							
Copper-Bearing Acid Open-Hearth Steel	A	Copper-Bearing	0.100	0.460	0.085	0.039		0.230	6							
Puddled Iron	A	Copper-Bearing	0.033	0.026	0.111	0.019	0.109	0.307	6							
Low-Copper Wrought Iron, Youngstown Sheet and Tube Co	B	Non-Copper-Bearing	0.030	0.050	0.124	0.019	0.210	0.021	6						1	
Total Sheets in Test									138	1	3	2	1	1	3	1
Total Failures to Date									....	1	4	6	7	8	11	12

[a] All specimens in the inspection on these dates were sand blasted to facilitate inspection.

PLATE I.
PROCEEDINGS, AM. SOC. TESTING MATS.
VOL. 36, PART I.
REPORT OF COMMITTEE A-5:
TOTAL IMMERSION TESTS

SED MARCH 1, 1927, IN SEA WATER AT U. S. NAVAL STATION, KEY WEST, FLA.

16 GAGE SHEETS

Failures on Dates of Inspections																																						
Mar. 10, 1931, 1470 Days	Jan. 13, 1932,[a] 1779 Days	Feb. 12, 1932, 1809 Days	Mar. 14, 1932, 1840 Days	July 13, 1932, 1961 Days	Aug. 12, 1932, 1991 Days	Sept. 14, 1932, 2024 Days	Nov. 14, 1932, 2085 Days	Jan. 11, 1933,[a] 2143 Days	Mar. 14, 1933, 2205 Days	Apr. 15, 1933, 2237 Days	May 15, 1933, 2267 Days	June 15, 1933, 2298 Days	July 15, 1933, 2328 Days	Aug. 14, 1933, 2358 Days	Sept. 19, 1933, 2394 Days	Oct. 17, 1933, 2422 Days	Nov. 16, 1933, 2452 Days	Dec. 15, 1933, 2481 Days	Jan. 22, 1934,[a] 2519 Days	Apr. 20, 1934, 2607 Days	June 21, 1934, 2669 Days	July 20, 1934, 2698 Days	Aug. 20, 1934, 2729 Days	Sept. 21, 1934, 2761 Days	Oct. 23, 1934, 2793 Days	Nov. 22, 1934, 2823 Days	Dec. 21, 1934, 2852 Days	Jan. 22, 1935,[a] 2884 Days	Feb. 25, 1935, 2918 Days	Apr. 24, 1935, 2976 Days	May 23, 1935, 3005 Days	June 24, 1935, 3037 Days	July 23, 1935, 3066 Days	Aug. 23, 1935, 3097 Days	Oct. 24, 1935, 3159 Days	Nov. 22, 1935, 3188 Days	Jan. 24, 1936,[a] 3251 Days	Feb. 24, 1936, 3282 Days
	1, 13							2	1			2					5		28 4				4										16					22
	201		1		205		204	201		10	202		206						18							15			26			31						
2	11 417, 419	10			419	418	9	6					10				11					8	3	7		21		27 7	20		14		12	12		6		
	501									1		4			501		503		22 13, 15 505				26		16		502, 502							12	11	6	10	
		32	12															2					11, 13					25		10				14 9			12 12	
							18					8				1, 34			13											15								
	3			6										16	23		20			7																		
													1						2, 13														4				11	
								6										2	2	2	6																	
1	8	2	2	1	2	1	3	4	1	2	1	3	3	1	2	2	4	2	11	2	1	1	5	1	1	2	2	3	2	2	1	1	3	4	1	2	4	1
12	20	22	24	25	27	28	31	35	36	38	39	42	45	46	48	50	54	56	67	69	70	71	76	77	78	80	82	85	87	89	90	91	94	98	99	101	105	106

TABLE II.—REPORT ON TOTAL IMMERSION TESTS. SHEETS EXPOSED MARCH
No.

Group	Designation	Series	Description	Average Analysis, per cent						Number of Sheets in Test											
				Carbon	Manganese	Phosphorus	Sulfur	Silicon	Copper		Dec. 10, 1929,[a] 1019 Days	Feb. 5, 1930, 1066 Days	Mar. 1, 1930, 1090 Days	May 1, 1930, 1151 Days	Jan. 5, 1931,[b] 1400 Days	Feb. 5, 1931, 1431 Days	Aug. 6, 1931,[c] 1613 Days	Sept. 5, 1931, 1643 Days	Oct. 5, 1931, 1673 Days	Dec. 5, 1931, 1734 Days	Jan. 5, 1932, 1765 Days
AA	Bessemer Steel	A	Non-Copper-Bearing	0.053	0.420	0.087	0.041		0.013	6											
ZZ	Bessemer Steel, Youngstown Sheet and Tube Co.	B	" " "	0.078	0.412	0.100	0.038		0.013	6											
II	Copper-Bearing Bessemer Steel	A	Copper-Bearing	0.057	0.390	0.098	0.066		0.247	6											
ZZ3	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co.	B		0.088	0.317	0.092	0.045	0.000	0.276	6											
BB	Open-Hearth Steel	A	Non-Copper-Bearing	0.063	0.338	0.030	0.057	0.078	0.122	6										39	
FF	Open-Hearth Steel	A	" " "	0.277	0.500	0.027	0.038	0.010	0.034	6									10		
OO	Low-Copper Open-Hearth Steel	A	" " "	0.117	0.377	0.010	0.027	0.005	0.030	6			15					33			32
MM	Open-Hearth Steel, Alan Wood Steel Co.	B	" " "	0.105	0.420	0.011	0.032	0.005	0.052	6											
ZZ4	Open-Hearth Steel, Youngstown Sheet and Tube Co.	B	" " "	0.028	0.392	0.042	0.029		0.028	6						420					422
GG	Open-Hearth Steel	A	Copper-Bearing	0.293	0.506	0.028	0.039	0.010	0.217	6											
HH	Copper-Bearing Basic Open-Hearth Steel	A	" "	0.073	0.372	0.015	0.027		0.228	6		32									
TT	Copper-Bearing Steel, Newport Rolling Mill Co.	B	" "	0.076	0.305	0.010	0.020		0.226	6							21				
ZZ5	Copper-Bearing Open-Hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.066	0.373	0.056	0.066		0.227	6											
CC	Low-Copper Pure Iron	A	Non-Copper-Bearing	0.020	0.031	0.004	0.033		0.065	6				18							
DD	Low-Copper Pure Iron	A	" " "	0.020	0.034	0.004	0.026		0.028	6	50			35						52	
SS	Low-Copper Pure Iron, American Rolling Mill Co.	B	" " "	0.014	0.017	0.006	0.023		0.028	6											
XX	Low-Copper Pure Iron, Inland Steel Co.	B	" " "	0.019	0.053	0.008	0.031		0.027	6											15
CCC	Copper-Bearing Pure Iron	A	Copper-Bearing	0.018	0.027	0.005	0.027	0.005	0.221	6											
UU	Copper-Bearing Pure Iron, Allegheny Steel Co.	B	" "	0.013	0.066	0.010	0.033		0.243	6											
VV	Copper-Bearing Pure Iron, Whitaker-Glessner Co.	B	" "	0.016	0.033	0.007	0.022		0.289	6											
KK	Copper-Bearing Acid Open-Hearth Steel	A	Copper-Bearing	0.120	0.418	0.085	0.042		0.240	6											
EE	Puddled Iron	A	Copper-Bearing	0.030	0.040	0.124	0.018	0.130	0.334	6										15	
YY	Low-Copper Wrought Iron, Youngstown Sheet and Tube Co.	B	Non-Copper-Bearing	0.030	0.052	0.123	0.018	0.193	0.024	6					7				8		
	Total Sheets in Test									138	1	1	1	2	1	1	1	1	2	3	3
	Total Failures to Date									....	1	2	3	5	6	7	8	9	11	14	17

[a] All specimens in the inspection on these dates were sand blasted to facilitate inspection.
[b] All specimens in the inspection on this date had been sand blasted on May 27, 1930, and October 15, 1930.
[c] All specimens in the inspection on this date had been sand blasted on April 6, 1931.
[d] All specimens in the inspection on this date had been sand blasted on April 5, 1932.

PLATE II.
PROCEEDINGS, AM. SOC. TESTING MATS.
VOL. 36, PART I.
REPORT OF COMMITTEE A-5:
TOTAL IMMERSION TESTS.

MARCH 7, 1927, IN SEA WATER AT U. S. NAVY YARD, PORTSMOUTH, N. H.

No. 16 Gage Sheets

Failures on Dates of Inspections

Days	Dec. 5, 1931, 1734 Days	Jan. 5, 1932, 1765 Days	Feb. 5, 1932, 1796 Days	July 5, 1932,[d] 1497 Days	Aug. 5, 1932, 1978 Days	Sept. 5, 1932,[e] 2009 Days	Dec. 6, 1932, 2101 Days	Jan. 5, 1933, 2131 Days	Mar. 6, 1933, 2191 Days	Apr. 5, 1933,[e] 2221 Days	June 5, 1933, 2282 Days	Aug. 7, 1933, 2345 Days	Sept. 5, 1933,[e] 2374 Days	Oct. 5, 1933, 2404 Days	Dec. 5, 1933, 2465 Days	Feb. 6, 1934, 2528 Days	Mar. 5, 1934, 2555 Days	Apr. 5, 1934,[e] 2586 Days	May 7, 1934, 2618 Days	June 5, 1934, 2648 Days	July 5, 1934, 2678 Days	Aug. 6, 1934, 2710 Days	Sept. 6, 1934, 2741 Days	Oct. 5, 1934,[e] 2770 Days	Nov. 5, 1934, 2801 Days	Dec. 5, 1934, 2831 Days	Jan. 4, 1935, 2861 Days	Feb. 5, 1935, 2893 Days	Mar. 6, 1935,[e] 2922 Days	Apr. 5, 1935, 2951 Days	June 5, 1935, 3012 Days	July 8, 1935, 3045 Days	Sept. 6, 1935,[e] 3107 Days	Oct. 4, 1935, 3133 Days	Nov. 5, 1935, 3163 Days	Dec. 5, 1935, 3195 Days	Jan. 6, 1936, 3227 Days	Feb. 5, 1936, 3257 Days	Mar. 6, 1936,[e] 3287 Days
						31			5				34					8											43, 49 7, 7, 8, 14	52		46							
																213		33					38		206	213	43 208		37, 40				208		209		45		
	39	32 422	35	422	34	27	11			28			11 40 420	31				10			426	426		48		37	12		42			29	12 42			53		47	50
							37, 44						27			510		10	10 507			42 505	40 506			30			11, 12 46		34	509	12 39	11	24				509
	52	15		42	16			27		25						42	28 29	27 40 40 30			20 47 38	26		24	37			30 28											
						21							37							21									32, 37 49							25, 33 54, 42	40	35 43	30, 32 24
						26					47												52			57			50			32							
	15											17													22 27				30										25
													9		9, 8		9																						
	3	3	1	2	2	4	3	1	1	2	1	1	7	1	2	3	3	8	2	1	4	4	4	2	4	4	3	2	17	1	1	4	5	1	2	5	2	3	6
	14	17	18	20	22	26	29	30	31	33	34	35	42	43	45	48	51	59	61	62	66	70	74	76	80	84	87	89	106	107	108	112	117	118	120	125	127	130	136

for publication as tentative the proposed Tentative Method of Test for Uniformity of Coating by the Preece Test (Copper Sulfate Dip) on Zinc-Coated (Galvanized) Iron or Steel Wire, appended hereto,[1] as described earlier in this report.

The subcommittee is continuing its work on methods for determining the weight and uniformity of zinc coatings on hardware and irregularly shaped articles. A large volume of work has already been done and the studies are being actively continued.

The subcommittee is compiling a bibliography on methods of determining properties of electroplated coatings which, when completed, will be circulated to members of Committee A-5 for comments and reference. This is in line with an earlier proposal that this subcommittee compile all methods of testing protective metallic coatings for iron and steel and carefully follow the development of new methods so that an up to date bibliography can be maintained on this subject. It is felt that the compilation of such a bibliography will be of considerable value to the industry.

Subcommittee VIII on Field Tests of Metallic Coatings (R. F. Passano, chairman).—The subcommittee has continued the periodic inspections of galvanized sheets and hardware, and its appended report provides a discussion of the data already published. Consideration is being given to extension of the hardware tests to provide a quantitative comparison of equal thicknesses of sherardized, hot-dipped, and electroplated zinc coatings on hardware specimens of identical shape. This latter phase of the work is still in the planning stage and will be covered in a subsequent report.

The Wire Test Program has been advanced steadily during the year, following quite closely the test program published in the 1934 annual report.[2] Splendid cooperation by both producers and the agricultural experiment stations of the participating universities has enabled the committee to further the work of collecting and fabricating test racks and test specimens. The enormously complicated job of collecting, sorting and preparing samples for exposure, and of assembling test rack materials for shipment to the test sites is being carried out by Mr. H. E. Smith, Assistant Director of Tests and Mr. C. L. Warwick, Director. It is anticipated that the installation of the test materials at their proper sites will have been completed by late fall.

It will be recognized that the Wire Test Program has been largely expanded to provide for the testing of fabricated fencing on a suitable scale and that the cost of doing the work will greatly exceed the funds originally at the disposal of the committee. An active drive for additional funds for this program is now under way and the committee wishes to take this opportunity to acknowledge the invaluable assistance which Mr. C. L.

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[1] See p. 645.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, p. 172 (1934).

Warwick has given in this work. A complete report of the Wire Tes Program will be published in the 1937 annual report.

The following officers were elected for the ensuing term of two years:

Chairman, F. F. Farnsworth.
First Vice-Chairman, W. G. Kelley.
Second Vice-Chairman, James Aston.
Secretary, T. R. Galloway.

This report has been submitted to letter ballot of the committee whic consists of 117 members; 86 members returned their ballots, of whom 8 have voted affirmatively and 1 negatively.

Respectfully submitted on behalf of the committee,

F. F. FARNSWORTH,
Chairman.

JAMES ASTON,
Secretary.

REPORT OF SUBCOMMITTEE VIII ON FIELD TESTS OF METALLIC COATINGS

Subcommittee VIII has held one general meeting since that during the 1935 annual meeting of the Society in Detroit, Mich. The inspection committees of the subcommittee have continued their periodic observations at the localities where corrugated galvanized sheets and coated hardware are exposed under the jurisdiction of Subcommittee VIII. The special group, under the chairmanship of Mr. F. F. Farnsworth, having to do with the exposure of wire and fencing in accordance with a plan approved by letter ballot of this subcommittee in 1935, is making progress toward that end.

Previous reports of this subcommittee have presented the data gathered from the following three lines of investigation without attempting to compare them in a detailed way:

> *Project 1.*—Inspection of galvanized sheets by a committee under the chairmanship of Mr. M. E. McDonnell. The published reports have shown the time for the appearance of rust, the time required for perforation of sheets, and the extent of rusting as percentage of exposed area covered with rust at each inspection interval.
>
> *Project 2.*—Inspection of hardware, structural shapes, etc., coated with zinc, cadmium, and other metals, by a committee under the chairmanship of Mr. W. L. Maucher. The reports have shown percentage of exposed area covered with rust at each inspection interval.
>
> *Project 3.*—Inspection of samples electroplated with zinc, cadmium, and other metals by the National Bureau of Standards, and jointly observed in outdoor exposure tests by a committee of the American Electroplaters' Society and Subcommittee VIII. The reports have shown progress of rusting by a numerical rating scheme.

The present report attempts to relate the observations made on these three projects as regards performance at Brunot Island (Pittsburgh, Pa.), where the corrosion of various specimens has progressed far enough to attempt comparisons. The matter of relating the performance of electroplated coatings (Project 3) to the other two projects depends on the translation of the numerical "rating" into amount of rust.

Members of the Galvanized Sheet Inspection Committee have noted, at various times when they have been present at the test sites, percentage of rust on the electroplated zinc and cadmium specimens prepared at the Bureau of Standards. These unofficial observations have just preceded, or closely followed, an official examination made by members of the Joint

Inspection Committee who used the numerical rating scheme. While there has been a nominal relationship between "rating" and percentage of exposed surface covered with rust, the two independent sets of observations offer an actual comparison. The result is shown in Fig. 1. The curve is the nominal relationship and a repetition of Fig. 1 from Research Paper No. 867 of the National Bureau of Standards,[1] whereas, the points are the actual comparison to which reference has just been made. There seems to be no large discrepancy between the two.

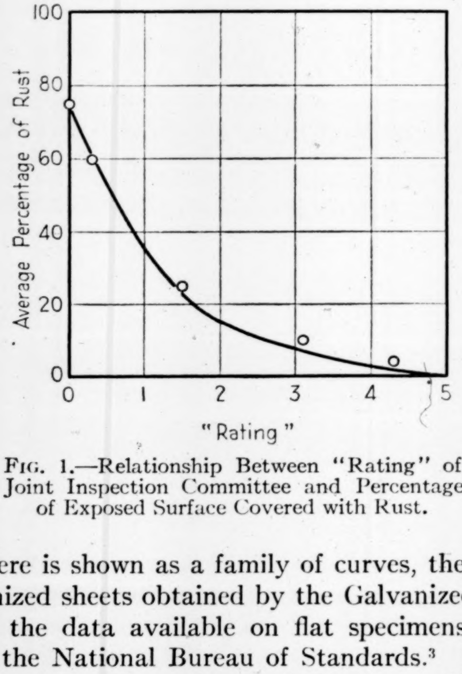

FIG. 1.—Relationship Between "Rating" of Joint Inspection Committee and Percentage of Exposed Surface Covered with Rust.

In Fig. 2, there is shown as a family of curves, the data available on corrugated galvanized sheets obtained by the Galvanized Sheet Inspection Committee,[2] and the data available on flat specimens plated with zinc and cadmium at the National Bureau of Standards.[3] In this figure, the weight of coating on each class of material has been shown in ounces per square foot of surface. In calling attention to this family of curves, it should be borne in mind that the specimens plated at the Bureau of Standards were 4 by 6 in., and that the galvanized sheet specimens were 26 by 30 in. (28 by 30 in. before corrugating). The two experiments were also started at different times; the corrugated sheets were exposed April 21 1926, and the platings prepared at the Bureau of Standards were exposed April 27, 1932.

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[1] William Blum, Paul W. C. Strausser, and Abner Brenner, "Corrosion-Protective Value of Electrodeposited Zinc and Cadmium Coatings on Steel," National Bureau of Standards, *Journal of Research*, Vol. 16, No. 2, p. 185 (1936).

[2] These curves are extensions of those shown in these reports previously. See *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 151, Fig. 2 (1933); Vol. 34, Part I, p. 164, Fig. 2 (*b*), (1934); Vol. 35, Part I, p. 89, Fig. 1 (*b*), (1935).

[3] *Loc. cit., Research Paper No. 867*, Fig. 4.

This family of curves shows that after rust has started, it spreads quickly over the surface of lightly coated specimens, and more slowly over the surface of specimens heavily coated. This indicates that the light coatings are more uniform than the heavy ones. Better uniformity seems to have been attained with lightly coated galvanized sheets than with heavily coated ones. There is also an indication that the small, laboratory electroplated samples are more uniform than galvanized sheets carrying

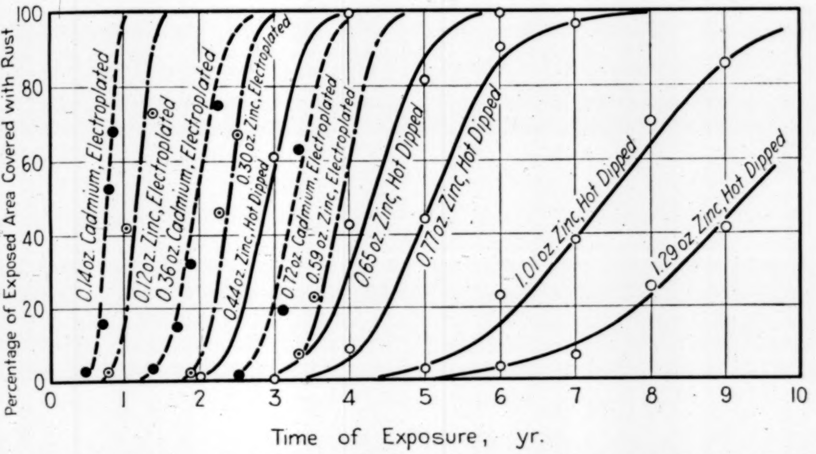

FIG. 2.—Progressive Development of Rust at Brunot Island on 4 by 6-in. Steel Specimens Plated with Cadmium and Zinc and on Corrugated Galvanized Sheets.

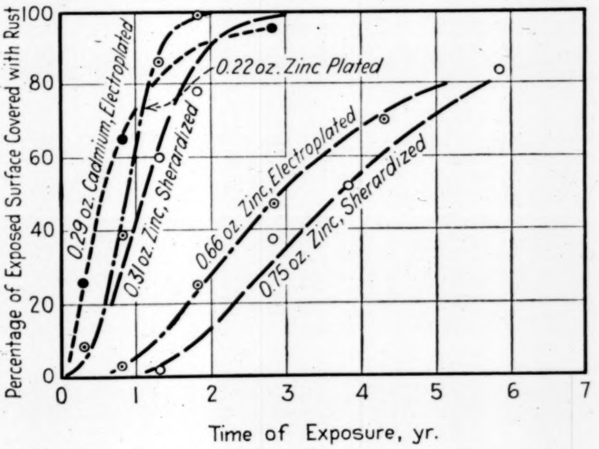

FIG. 3.—Progressive Development of Rust at Brunot Island on Hardware Specimens Coated with Zinc and Cadmium.

about the same weight of coating. (Compare the steepness of curves for 0.59 oz. plated zinc and 0.65 oz. galvanized sheet.)

Figure 3 is a representation of the progressive development of rust on zinc-plated, sherardized, and cadmium-plated hardware. To obtain the points for drafting these curves, the inspection data have been analyzed by methods which appear to be the best available, but the analysis involves more uncertainty than obtains for the data illustrated in Fig. 2. The uncertainties are due primarily to questions of exactness of weight of coating data and to the fact that the specimens represent a miscellany of shapes having various areas.

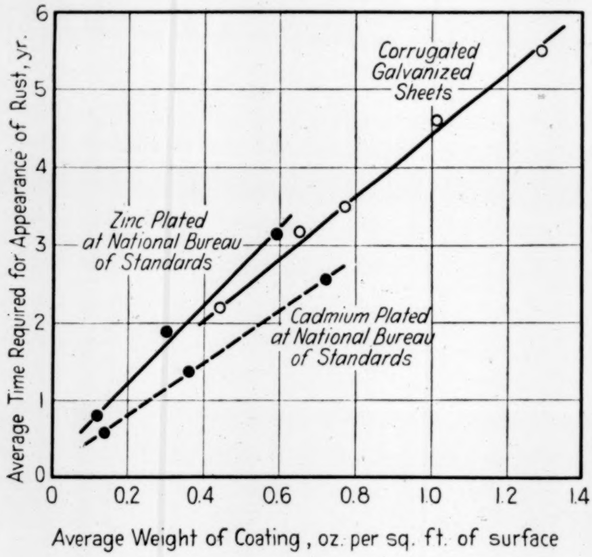

FIG. 4.—Relationship Between Weight of Coating and Time at Which Rust First Appears on Specimens at Brunot Island. (See Fig. 2, 1935 Report[1] of Subcommittee VIII, A-5, of which this figure is repetition in part.)

The weight of coating determinations were made on one sample specimen. The weight of coating on the specimen analyzed is assumed to be representative of the coating on its 15 exposed companion samples (3 at each of 5 locations). However, in some cases, the weight of coating figure available is probably not typical of all the other 15 specimens because there are occasional instances of rust developing faster or slower than would be expected from the nominal weight of coating. In order to overcome such irregularities, each curve in Fig. 3 represents the deportment of a group of several items.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 92 (1935).

The items comprising any one group are a selection of items which have performed about alike in the rate of rust development. Groupings on which the curves are based are as follows:

Light Weight Sherardized Group (13 items, 3 specimens per item):
  8 items in the range 0.12 to 0.42 oz. per sq. ft.
  1 item with 0.85 oz. per sq. ft.
  4 items lacking weight of coating determination.
    Average of the 9 available determinations............... 0.31 oz. per sq. ft.
Heavy Weight Sherardized Group (34 items, 3 specimens per item):
  20 items in the range 0.50 to 0.92 oz. per sq. ft.
  5 items below 0.50 oz. per sq. ft.
    (Specifically 0.47; 0.46; 0.42; 0.32; and 0.28)
  4 items above 0.92 oz. per sq. ft.
    (Specifically 1.82; 1.25; 1.21; 1.15)
  5 items lacking weight of coating determinations
    Average of the 29 available determinations.............. 0.75 oz. per sq. ft.
Lightly Electrogalvanized Group (8 items, 3 specimens per item):
  7 items in the range 0.18 to 0.33 oz. per sq. ft.
  1 item lacking weight of coating determination
    Average of the 7 available determinations............... 0.22 oz. per sq. ft.
Heavily Electrogalvanized Group (29 items, 3 specimens per item):
  19 items in the range 0.45 to 0.85 oz. per sq. ft.
  3 items above 0.85 oz. per sq. ft.
    (Specifically 0.89; 1.09; and 3.41)
  7 items below 0.45 oz. per sq. ft.
    (Specifically 0.37; 0.35; 0.29; 0.24; 0.21; 0.16; and 0.16)
    Average of the 29 available determinations.............. 0.66 oz. per sq. ft.
Cadmium Plated Group (45 items, 3 specimens per item):
  28 items in the range 0.10 to 0.30 oz. per sq. ft.
  6 items above 0.30 oz. per sq. ft.
    (Specifically 0.32; 0.43; 0.50; 0.65; 1.40; and 1.49)
  3 items below 0.10 oz. per sq. ft.
    (Specifically 0.09; 0.07; and 0.04)
  8 items lacking weight of coating determinations
    Average of the 37 available determinations.............. 0.29 oz. per sq. ft.

Almost all of the sherardized, electrogalvanized, and cadmium-plated samples on the racks are included in the above groups. The excluded items are those showing discrepancies in rate of rust development at different locations, or else they are composite items (such as bolts and nuts) for which it is difficult to calculate weight of coating because of the component parts carrying different amounts of coating. There are also four electrogalvanized items excluded which are performing as though they carried a very heavy coating.

The above groupings are arranged regardless of shape or size of specimens, and the percentage of rusted areas are averaged without taking into account that the areas of specimens differ. The seriousness of these assumptions and their effect on the result is a matter of conjecture.

It will be seen at once that the curves representing the hardware specimens are not so steep as those representing the corrugated sheets and flat electroplated specimens. So far as it is possible to tell, this means that the coatings on hardware were less uniform than the coatings on sheets, and differed significantly in weight on different parts of the specimens; as at threads, recesses of angles, etc. Such non-uniformity of coating is reflected not only by the time at which rust first appears, but by the length of time that traces of coating remain. When comparing coatings on hardware with those on flat objects, it is chiefly a question of shape and ability of the coating method to reach with equal facility all parts of the object to be coated.

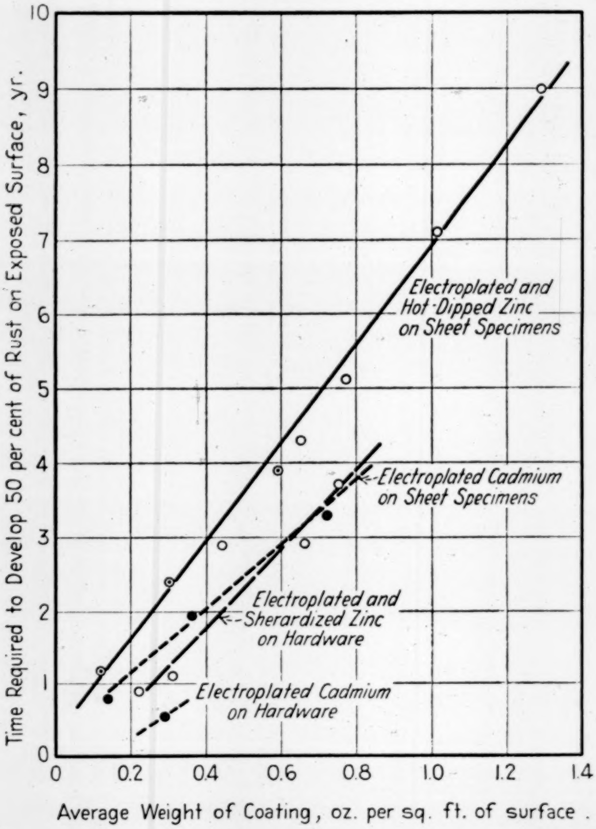

FIG. 5.—Relationship Between Weight of Coating and Time at Which Exposed Surface is Half Covered with Rust at Brunot Island, for (*a*) Flat Specimens Coated with Zinc and Cadmium, and (*b*) Hardware Specimens Coated with Zinc and Cadmium.

Certain comparisons can be drawn between the electroplated specimens and the hot-dip zinc-coated sheets as regards the time required for the appearance of rust. In previous committee reports the time for the appearance of rust has been tabulated as "Record of Coating Failures."[1] Actually, in the case of lightly coated galvanized sheets, rusting had appeared, and had extended to cover about 3 per cent of the sheet area after an exposure equivalent to the *average* time at which the lightly coated sheets first showed rust. Therefore, it seems fair to compare the plated and lightly coated galvanized sheets on the basis of time required for the development of rust over 3 per cent of their areas. These comparisons are illustrated in Fig. 4.

From the curves in Fig. 4, it appears that the zinc-coated specimens under test which were electroplated under laboratory conditions were free from rust a little longer than the lightly galvanized sheet specimens. However, if the two are compared on the basis of the time required for 50 per cent of the area to become covered with rust, there is no apparent difference in the protection obtained.[2] This is brought out in Fig. 5.

Both Figs. 4 and 5 bring out the fact that the protection of cadmium coatings is less than that afforded by zinc coatings of the same weight. Figure 5 also illustrates that zinc coatings on hardware give less protection than zinc coatings of the same weight on sheets.

This report has been submitted to letter ballot to the members of Subcommittee VIII, which consists of 47 members; 34 members returned their ballots, of whom 32 have voted affirmatively, 1 negatively, and 1 member marked his ballot "not voting."

Respectfully submitted on behalf of the subcommittee,

R. F. PASSANO,
Chairman.

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[1] The Galvanized Sheet Inspection Committee considered that the "life" of the coating on a specimen was determined by the time at which rust first appeared. With several specimens in each class, it can be seen that there was a finite percentage of rust on the sheet specimens after an exposure which represented the *average* life of coating.

[2] The indication that the amount of protection obtained from a zinc coating depends on its weight primarily rather than the method used to apply it has been stated in these reports previously as well as in other places. See *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I (1933); Vol. 30, Part II, p. 456 (1930); also *Transactions*, Am. Electrochemical Soc., Vol. 58, p. 23 (1930); also Symposium on the Outdoor Weathering of Metals and Metallic Coatings, Washington Regional Meeting, Am. Soc. Testing Mats., p. 1 *et seq.*, p. 28 *et seq.* (1934). (Available as separate publication.)

REPORT OF COMMITTEE A-6

ON

MAGNETIC PROPERTIES

Committee A-6 on Magnetic Properties held two meetings during the year, one in Philadelphia, Pa., on December 13, 1935, and the other in Pittsburgh, Pa., on March 3, 1936.

Subcommittee IV on Tests of Electrical Sheet Having Pronounced Directional Properties (B. M. Smith, chairman) has completed its work and has been discharged.

The resignation of Mr. Reinhold Schempp of the Halcomb Steel Co. was accepted with regret. No successor to Mr. Schempp has been appointed. Mr. W. R. Koch of the U. S. Army Air Corps, Wright Field, Dayton, Ohio, has been appointed a member of the committee. Mr. G. L. Gaalaas of the Empire Sheet and Tin Plate Co. has been appointed a member of the committee to succeed Mr. J. P. Barton, who is now with the American Sheet and Tin Plate Co. Mr. Barton's membership has automatically lapsed since Mr. Romig is the representative of the American Sheet and Tin Plate Co. on the committee.

In line with the suggestion of the Society, Committee A-6 requested Mr. P. H. Dike to prepare a set of by-laws to govern the proceedings of the committee. At the next meeting definite action will be taken on the adoption of these by-laws. The proposed by-laws provide for a vice-chairman and the appointment of an advisory committee to consist of the officers and two additional members elected by the committee. Also, the present subcommittees will perhaps be discharged and new ones appointed which will have a different scope and be more permanent in character.

The election of officers for the ensuing term of two years has resulted in the re-election of Mr. Thomas Spooner as chairman and Mr. R. L. Sanford as secretary. Mr. P. H. Dike has been elected vice-chairman and the two members of the Advisory Committee, in addition to the officers, are Messrs. L. E. Howard and B. M. Smith.

RECOMMENDATIONS AFFECTING STANDARDS

I. Adoption of Tentative Standard as Standard:

The committee recommends that the Tentative Definitions of Terms with Units and Symbols, Relating to Magnetic Testing (A 127 – 35 T)[1] be referred to letter ballot of the Society for adoption as standard to replace the present Standard Definitions A 127 – 34. This recommendation is being made at this time so that the definitions in their latest form may be included in the 1936 edition of the Book of A.S.T.M. Standards. With the adoption of the definitions as standard it is recommended that they be revised as follows:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 726 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 265.

Maxwell.—Change to read as follows by the addition of the italicized words:

Maxwell.—The flux through a surface of uniform induction when the product *of the normal component* of the induction in gausses and the surface area in square centimeters is unity.

Intrinsic Induction in a Ferromagnetic Material.—Change the equation accompanying this definition from its present form: namely,

$$B_4 = B - H$$

to read as follows:

$$B_4 = B - \mu_v H$$

Magnetiz Flux.—Change to read as follows by the addition of the italicized words:

Magnetic Flux (Flux), ϕ.—The surface integral *of the normal component* of the magnetic induction over a given area.

Magnetic Induction.—Change from its present form: namely,

Magnetic Induction (*Magnetic Flux Density*), *B*.—The vector magnetic quantity accompanying and having the same direction at a point in an isotropic medium as the magnetizing force at the point, but having a magnitude which is dependent upon the properties of the medium.

Note.—The magnitude is measured by the electromotive force produced in an electric circuit when the circuit is linked with the induction at a definite time rate. Thus:

$$e = N \frac{dB}{dt}$$

where e is the electromotive force produced in a circuit which is linked N times with the magnetic field of unit cross-sectional area and of uniform induction B.

to read as follows:

Magnetic Induction (*Magnetic Flux Density*), *B*.—The vector magnetic quantity which, at any point in a magnetic field, determines the electromotive force induced in an electric circuit which is linked with the field at a definite time rate. Thus:

$$e = N \frac{dB}{dt}$$

where e is the electromotive force produced in a circuit which is linked N times with a magnetic field of unit cross-sectional area and of uniform induction B.

Note.—In isotropic materials, magnetic induction and magnetizing force have the same (or opposite) direction. In anisotropic materials (such as single crystals and fabricated metals) the direction of the induction is a function of the magnitude of the magnetizing force, the orientation of the crystal axes of the material and its previous condition of magnetization.

Magnetizing Force.—Change the first sentence to read as follows by the addition of the italicized words:

> That vector magnetic quantity arising from electric currents which at a given point *in a continuous homogeneous medium* depends only on the position of the point relative to the currents and on their magnitude.

Permeability Space.—After this term, insert the symbol: μ_v.

II. Revision of Standard:

The major change which the committee is recommending in the Standard Methods of Test for Magnetic Properties of Iron and Steel (A 34 - 33)[1] is the adoption of an induction for core loss tests of 15 kilogausses instead of 14 kilogausses. It is believed that the higher induction gives a better indication of the quality of the material when it is to be used in power transformers and for rotating machines. The higher induction also agrees better with European practice and will be of advantage to manufacturers shipping to foreign countries. In connection with the alternating-current tests at low inductions, a sample 28 cm. in length instead of 25 cm. is suggested, with the use of a double lap joint instead of an alternate butt and lap joint.

In view of the fact that a new edition of the Book of Standards is to be published this year, it is believed advisable to recommend that the changes mentioned above together with certain other minor modifications and corrections be immediately adopted as standard. The committee accordingly asks for the necessary nine-tenths vote at the annual meeting in order that the methods in their revised form, as appended hereto,[2] may be referred to letter ballot of the Society for immediate adoption.

It is also recommended that the revisions proposed in these methods for publication as tentative in 1935[3] be adopted as standard, with a modification in the proposed revision of Section 1 and the omission of the revision proposed in Sections 18 and 20. These revisions as modified[4] have been incorporated in the completely revised methods appended hereto.[2]

The above recommendations have been submitted to letter ballot of the committee, which consists of 17 members, the results being as follows:

Items	Affirmative	Negative	Ballots Marked "Not Voting"
I. ADOPTION OF TENTATIVE STANDARD AS STANDARD			
Definitions of Terms, with Units and Symbols, Relating to Magnetic Testing (A 127 - 35 T):			
Approval of Revisions	13	0	0
Adoption as Standard	15	0	0
II. PROPOSED REVISION OF STANDARD			
Methods of Test for Magnetic Properties of Iron and Steel (A 34 - 33), immediate adoption	15	0	0

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[1] 1933 Book of A.S.T.M. Standards, Part I, p. 396.

[2] See 1936 Book of A.S.T.M. Standards, Part I, p. 504.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1389 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 1515

[4] An additional revision was submitted at annual meeting, see Summary of Proceedings, p. 16.—ED.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Nomenclature and Definitions (W. J. Shackelton, chairman).—This subcommittee has not met during the year since no important suggestions for changes or additions to the nomenclature relating to magnetic testing have been offered. In recommending that the present Tentative Definitions A 127 – 35 T be adopted as standard, it is realized that it may be desirable within the next two or three years to recommend certain changes in the definitions as a result of the international adoption of the M.K.S. system of units in place of the c.g.s. system.

Subcommittee II on Alternating Current Tests at Low Inductions (R. L. Sanford, chairman).—Two subjects have been considered by this subcommittee which have led to the proposed revision of the Standard Methods of Test for Magnetic Properties of Iron and Steel (A 34 – 33), as appended hereto.[1] The first is with reference to the adoption of the double lap joint instead of the alternate butt and lap joint. It has been found by experiments that the former gives more reproducible results and requires less care in stacking. It requires a sample 28 cm. in length instead of 25 cm. The effective mean length of magnetic path has been assumed to be 94 cm. as a result of rather limited experiments. Further test results may indicate a modification of this assumption, two or more values being required, possibly depending on the permeability of the material.

The second subject of importance to this subcommittee was that of the magnetic drift with time as a result of demagnetization. This drift is rapid at first and is largely completed at the end of 24 hr. The committee has prepared a research program from which a test procedure should develop which would eliminate uncertainties in testing due to this effect; perhaps also there will result some suitable short-time stabilizing procedure.

Subcommittee III on Tests at High Magnetizing Forces (L. E. Howard, chairman).—New uniform bars of material of high coercive force have been tested by members of the committee with good agreement. New types of permeameters of high magnetizing force are also being experimented with to determine their accuracy. It is hoped that within another year more reliable accuracy limits may be specified for the permeameters which have been approved for tests of this class of material.

Subcommittee V on Core Loss Tests of Electrical Sheet at High Inductions (B. M. Smith, chairman).—As a result of a series of round-robin tests on 10-kg. core loss samples at various inductions from 10 to 16 kilogausses, it has been decided to recommend to the Society the adoption of the 15-kilogauss test instead of the 14-kilogauss test since the former is believed to be a more representative test for material which is to be used at high inductions.

The results of the tests were in sufficiently good agreement so that with proper precautions it is believed that values of required accuracy will result. Fortunately, it was found that corrections for form factor, using the flux voltmeter, are the only ones required, the air-leakage and eddy-current corrections being unnecessary since to a certain extent these errors compensate each other. For the 5-kg. sample and the 15-kilogauss test, special coils of smaller cross-section will be required in order to keep the leakage flux down to sufficiently low values.

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[1] See 1936 Book of A.S.T.M. Standards, Part I, p. 504.

This report has been submitted to letter ballot of the committee which consists of 17 members; 15 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

THOMAS SPOONER,
Chairman.

R. L. SANFORD,
Secretary.

REPORT OF COMMITTEE A-10
ON
IRON-CHROMIUM, IRON-CHROMIUM-NICKEL AND RELATED ALLOYS

Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys has held one meeting during the year, in Pittsburgh, Pa., on Match 5, 1936, during the spring group meetings of A.S.T.M. committees. Several changes in committee personnel have occurred resulting in a present membership of 63, of whom 26 are classed as producer, 27 as consumer, and 10 as general interest members.

Mr. T. H. Nelson resigned the vice-chairmanship of the committee and also the chairmanship of Subcommittee I on Classification of Data. Mr. C. E. MacQuigg has taken over the activities of Subcommittee I but the selection of a successor to Mr. Nelson as vice-chairman is still to be made.

Mr. E. S. Taylerson succeeded Mr. W. R. Huey, resigned, as chairman of Subcommittee IV on Methods of Corrosion Testing.

Mr. C. A. Scharschu has recently tendered his resignation as chairman of Subcommittee V on Mechanical Testing; Mr. V. N. Krivobok has accepted the chairmanship.

Mr. F. B. Olcott resigned the chairmanship of Subcommittee VII on Welding. The direction of this subcommittee has been taken over by Mr. L. C. Bibber.

The organization of the new Subcommittee XI on Specifications for Tubular Products has been initiated by the selection of Mr. Newell Hamilton as chairman.

Subsequent to the 1935 annual meeting, Committee A-10 presented to the Society through Committee E-10 on Standards the following seven new tentative specifications. These were accepted[1] for publication by Committee E-10 at a meeting held on August 22, 1935, and appear in the 1935 *Proceedings*.[2]

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[1] In submitting these specifications to Committee E-10 on Standards, Committee A-10 reported the following results of the letter ballot vote of a total of 48 ballots returned from a committee membership of 65: Specifications A 171, A 172 and A 173, affirmative 38, negative 3, ballots marked "not voting" 7; Specifications A 174, affirmative 37, negative 3, ballots marked "not voting" 8; Specifications A 175, affirmative 38, negative 1, ballots marked "not voting" 9; Specifications A 176, affirmative 36, negative 4, ballots marked "not voting" 8; Specifications A 177, affirmative 37, negative 2, ballots marked "not voting" 9.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, pp. 635 to 677 (1935); also 1935 Book of A.S.T.M. Tentative Standards, pp. 161 to 203.

Tentative Specifications for:

24 per cent Chromium, 12 per cent Nickel Alloy Steel Castings (A 171 – 35 T)
25 per cent Chromium, 20 per cent Nickel Alloy Steel Castings (A 172 – 35 T)
28 per cent Chromium, 9 per cent Nickel Alloy Steel Castings (A 173 – 35 T)
20 per cent Nickel, 9 per cent Chromium Alloy Steel Castings (A 174 – 35 T)
35 per cent Nickel, 15 per cent Chromium Alloy Steel Castings (A 175 – 35 T)
Soft Corrosion-Resisting Chromium Steels (Sheets, Flats, Strip) (A 176 – 35 T
High-Strength Corrosion-Resisting Chromium-Nickel Steels (Sheets and Strips
(A 177 – 35 T)

At a Symposium on "High-Strength Constructional Metals," held during the Regional Meeting in Pittsburgh, Pa., Mr. E. E. Thum presented a paper entitled "Corrosion-Resisting Steels," which summarizes the present development of alloys falling within the scope of Committee A-10. A further discussion of these alloys with particular reference to service failures is contemplated in the coming year. This will likely take the form of an informal round-table discussion between producers and consumers and others interested in this important subject.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Classification of Data (C. E. MacQuigg, chairman).—This subcommittee held a meeting on May 28 in New York City, at which time it reviewed the work previously done and outlined a new program which, if carried to completion, will result in a third summary of data on alloys within the scope of the committee, by June, 1937; these will not be essentially producers' data but will have the approval of the committee.

Subcommittee IV on Methods of Corrosion Testing (E. S. Taylerson, chairman).—At a recent meeting, the previous work of this subcommittee was reviewed and a new program discussed. From the discussion it was apparent that there was no demand for extensive tests and that there was some overlapping of the scope of the work of this committee with that of Subcommittee VI on Metallography, especially with reference to the Strauss embrittlement test. The discussion further brought out the feeling that the work of this subcommittee should not be entirely confined to methods of testing for corrosion resistance but should also include some tests to determine the utility of the various alloys. In case no agreement is reached among members of the subcommittee as to the activities to be undertaken, these will be definitely settled through the Advisory Committee.

Subcommittee V on Mechanical Testing (V. N. Krivobok, chairman).—The program for the study of elastic properties of the 18 per cent chromium 8 per cent nickel types of steel in the various states of heat treatment and cold working has been outlined and work has been undertaken.

Subcommittee VI on Metallography (C. E. MacQuigg, chairman).—This subcommittee is engaged in a study of grain-boundary precipitation in 18 per cent chromium, 8 per cent nickel alloy with the object of determining the chemical composition of the precipitate. A statement regarding the progress of the work will likely be made at the next meeting of the committee.

Subcommittee VII on Welding (L. C. Bibber, chairman).—This subcommittee prior to being reorganized by the new chairman made little progress during the past year in arriving at any definite standards for welding. A proposed specification was prepared and circulated to the members but it has been extremely difficult to obtain any unanimity of opinion. The specification for welded construction was subsequently withdrawn. It seems likely that the subcommittee will devote its attention to the study of materials suitable for welding rather than to specify methods of welding or testing of welded structures.

In reorganizing the work of Subcommittee VII, cognizance will be taken of the formation of a research group on welding of heat- and corrosion-resistant alloys under the sponsorship of the Engineering Foundation. It is proposed that contact be established with Subcommittee XXI on Steel for Welding, of Committee A-1 on Steel so that duplication of effort will be avoided.

Subcommittee VIII on Specifications for Wrought Products (F. B. Foley, temporary chairman).—This subcommittee is working on the preparation of specifications for some of the types of products falling within its jurisdiction.

Subcommittee IX on Specifications for Flat Products (C. E. Snyder, chairman).—The three tentative specifications covering flat rolled products, as prepared by this subcommittee, have been in effect since they were approved last June. The fact that there has been very little comment respecting these specifications may be interpreted as being favorable. The present specifications for the 18 per cent chromium, 8 per cent nickel alloys do not include titanium or columbium stabilized materials, hence the subcommittee will now consider the advisability of modifying the specifications to include these materials.

Subcommittee X on Specifications for Castings (W. J. Jeffries, chairman).—This subcommittee has prepared another specification dealing with castings of chromium-nickel steel, namely, proposed Specifications for 20 per cent Chromium, 9 per cent Nickel Alloy Steel Castings (18 and 8 Type). Questions concerning the relationship of several A-10 specifications to others prepared by Subcommittee XXII of Committee A-1 will delay the presentation of the above specification to the Society for publication as tentative until some time during the coming year.[1]

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[1] Subsequent to the annual meeting Committee A-10 presented these specifications as tentative to the Society through Committee E-10 on Standards, see Editorial Note, p. 122.—ED.

At a meeting of the subcommittee held in Pittsburgh, Pa., during March 1936, W. J. Jeffries was reelected chairman for the ensuing two years. Mr. F. B. Olcott resigned membership on the subcommittee and several additional members were added to the personnel.

The election of officers for the ensuing term of two years resulted in the re-election of the present incumbents.

This report has been submitted to letter ballot of the committee which consists of 63 members; 51 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

JEROME STRAUSS,
Chairman.

H. D. NEWELL,
Secretary.

EDITORIAL NOTE

Subsequent to the annual meeting Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys presented to the Society through Committee E-10 on Standards proposed Tentative Specifications for 20 per cent Chromium, 9 per cent Nickel Alloy Steel Castings. These specifications were accepted by Committee E-10 on October 14, 1936, and appear on p. 639.

REPORT OF THE RESEARCH COMMITTEE
ON
FATIGUE OF METALS

During the past year the cooperative arrangement with *Metals and Alloys*, referred to in previous reports, has been continued, and monthly abstracts of articles concerning fatigue of metals have appeared in that journal.

The cooperative investigation of X-ray diffraction, which has been carried on by this committee and the Subcommittee on X-ray Methods of the Society's Committee E-4 on Metallography, has been continued, and there is submitted, as an appendix to this report, a report on that investigation.

At the meeting of the Fatigue of Metals Committee at Pittsburgh in March, 1936, a number of items of interest were reported by various laboratories. These items seem of sufficient interest to be reported and are accordingly given below, but they should be regarded as suggestive rather than as conclusive:

Attempts to correlate X-ray diffraction with creep and fracture of lead showed results in line with those of the report given in the Appendix. X-ray diffraction diagrams give some evidence of the beginning of plastic slip, and possibly of the early stages of "creep," but so far have not given any evidence of the early stages of cracking.

X-ray diffraction had been successfully used to detect dendritic structure in the 18 per cent chromium, 8 per cent nickel group of steels, but not to detect minute cracks.

The National Carbon Co. has located small surface cracks by wetting a piece of metal in a solution of anthracene and carbon-tetrachloride, and then viewing the piece by ultraviolet light in a darkened room. The anthracene in the cracks becomes phosphorescent.

Reports of the use of magnaflux for detecting cracks stated that at the U. S. Naval Gun Factory it is believed that cracks $\frac{1}{16}$ in. below the surface can be located. Further unsuccessful attempts to use magnetic methods and audiophonic methods for detecting incipient fatigue cracks were reported.

Reports of results of French's "damage line" test[1] were given, indicating that this test may be very valuable in indicating the sensitivity of any given metal to damage by occasional overstress.

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[1] H. J. French, "Fatigue and the Hardening of Steels," *Transactions*, Am. Soc. Steel Treating, Vol. XXI, No. 10, October, 1933, p. 899.

A difference in plotting S–N diagrams in this country and in European laboratories was noted as causing some confusion. In European laboratories it is usual to draw such diagrams through the "optimum" points, while in this country it is a rather general practice either to draw a band representing the "scatter" of the data, or to draw an averaging diagram among the plotted points.

Fatigue tests of steel forgings were reported in which fatigue strength transverse to the "grain" of forging was lower than fatigue strength in a longitudinal direction. The opposite effect of direction was reported for aluminum forgings.

Preliminary tests were reported to determine whether the strength-reducing effect of notches is *additive* to the stress-reducing effect of corrosion-fatigue. Results are not yet conclusive.

Fatigue failures of wrought aluminum alloys under repeated (zero to maximum) compression were reported with endurance limits closely checking the limit for zero-to-maximum tension.

New fatigue testing machines were referred to, especially the Haigh-Robertson machine[1] for fatigue tests of wire, a fatigue testing machine for bending stress and torsional stress acting together in any desired ratio[2] (used by H. J. Gough at the British National Physical Laboratory), and the 200,000-lb. tension and compression machine operating at 125 cycles per minute used by Prof. W. M. Wilson at the University of Illinois.

Several high values of endurance ratio (ratio of endurance limit to tensile strength) have been reported. A ratio of 0.8 for cast iron was reported by H. J. Gough.[2] This checks the high ratio reported by Bulleid[3] some years ago, but not generally accepted then. Ratios of 0.70 and 0.75 were reported for certain steels.

This report has been submitted to letter ballot of the committee which consists of 16 members, 16 members returned their ballots all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

H. F. MOORE,
Chairman.

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[1] *Engineering* (London), Vol. 138, August 10, 1934, p. 139.
[2] *Proceedings,* Inst. Mechanical Engrs. (British), Vol. 131, October–December, 1935.
[3] *Engineering* (London), Vol. 122, October 1, 1926, p. 429.

APPENDIX

X-RAY DIFFRACTION AS A MEANS OF DETECTING IMPENDING FATIGUE FAILURE

An extensive study of the possibility of detecting damage to metallic material by repeated stresses has been carried out in the Metals Research Laboratory of the Carnegie Institute of Technology with the cooperation of the Research Committee on Fatigue of Metals and the Subcommittee on X-ray Methods of Committee E-4 on Metallography. Preliminary conclusions, presented in last year's report,[1] were that the widening of Debye lines from repeated stressing of aluminum alloys was negligible, and that, even in the case of a structural silicon steel, the widening was so small as to offer no hope for a practical method of detecting impending fatigue failure. A more sensitive method has been tested subsequently, involving a stationary specimen and photographic film in which the film shows a pattern of spots. The spots become diffuse when the crystal grains undergo plastic deformation, either in the preparation of the specimen or in its repeated stressing. To reveal the effect of repeated stressing, it is necessary first to remove by etching any cold-worked layer left by machining and polishing operations.

Spot patterns from numerous fatigue specimens of 0.19 per cent carbon steel, of structural silicon steel (0.36 per cent carbon, 0.34 per cent silicon), and of high carbon steel (0.85 per cent carbon) show that the distortion of grains is severe at the surface of a fatigue break or at the ends of a fatigue crack, and that at points removed from these places the distortion decreases with decreasing stress intensity down to stresses definitely below the yield point, proportional limit (as usually determined in careful tests) and endurance limit—provided the specimen has received a large number of cycles of stress. No distinct step or break in this steady decrease was found at the endurance limit, and in one case the patterns did not seem to change progressively, even though the specimen was rapidly approaching failure above the endurance limit. A brief test of the method as applied to copper likewise indicated changes from stressing below the endurance limit.

Extensive tests were made on aluminum (2SO) and on an aluminum alloy (3SO). Marked changes in the spot pattern were found whenever specimens had been stressed above the yield point, and practically no changes when they had been stressed below the yield point; but a corresponding statement could not be made with respect to stressing above and below the endurance limit. It is the stress intensity relative to the *yield strength,* not the *endurance limit,* that appears to be critical with regard to the amount of cold working as revealed by the diffraction patterns.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 111 (1935).

It is concluded that X-ray diffraction patterns do not register the progress of fatigue fracture, but, rather, the progress of cold work. It is generally conceded that below the endurance limit this cold work is not detrimental; so, only if the X-ray patterns of a material are calibrated in terms of fatigue tests on the same material could there be a possibility of measuring damage or predicting impending failure in structural elements subjected to unknown stresses. Tests on 0.19 per cent carbon steel indicated that even with such calibration the method is insensitive and unreliable when the number of stress cycles is only a few hundred thousand.

Respectfully submitted,

C. S. BARRETT,
R. F. MEHL,
R. L. TEMPLIN.

REPORT OF JOINT RESEARCH COMMITTEE
ON
EFFECT OF TEMPERATURE ON THE PROPERTIES OF METALS

PROGRESS REPORT TO THE SPONSOR SOCIETIES

There follows a review of the activities of the Joint Research Committee for the year ending June, 1936.

Meetings:

Three meetings were held—one in Detroit, Mich., in June, 1935, and two in New York City, in December, 1935, and May, 1936.

Membership:

Two additions were made to the membership of the committee; F. B. Foley, Director of Research, The Midvale Co., Philadelphia, and R. H. Aborn, Research Laboratory, United States Steel Corp., Kearny, N. J.

D. J. McAdam, Jr., was appointed to represent the National Bureau of Standards, Washington, D. C., succeeding Louis Jordan.

Finances:

The expenditures for sponsored researches at the Battelle Memorial Institute, since June, 1935, amounted to approximately \$3500. These payments were made from funds previously allotted from sources summarized in last year's report and covered mainly twelve months activities in the -yr. continuous creep tests of ferritic and austenitic steels.

Beginning in March, 1936, the Finance Committee, under the chairmanship of R. A. Bull, initiated a program for the procurement of additional funds for completion of current researches and to permit new projects to be undertaken.

Subscriptions made since March 23, 1936, for financially supporting the work of the Joint Research Committee are as follows:

(Listed in order as received by Joint Committee)

1. The International Nickel Co., Inc.	\$1000
2. Ajax Electrothermic Corp.	500
3. Henry Vogt Machine Co.	200
4. Dodge Steel Co.	200
5. The Wm. Powell Co.	100
6. Electro Metallurgical Co.	1000
7. Crane Co.	500
8. Lebanon Steel Foundry	200
9. Bethlehem Steel Co., Inc.	750

10.	Stockham Pipe Fittings Co	200
11.	Sivyer Steel Casting Co	200
12.	Climax Molybdenum Co	750
13.	Standard Oil Development Co	500
14.	American Chain Co., Inc	350
15.	The Texas Company	500
16.	The Midvale Co	250
17.	General Electric Co	1000
18.	Allis-Chalmers Manufacturing Co	250
19.	The Edward Valve and Manufacturing Co., Inc	100
20.	Westinghouse Electric and Manufacturing Co	750
21.	The Lunkenheimer Co	250
22.	Engineering Foundation	500
23.	Standard Oil Co. (Ohio)	100
24.	Babcock & Wilcox Co	400
25.	Allegheny Steel Co	400
26.	E. I. du Pont de Nemours and Co., Inc	500
27.	Standard Oil Co. of California	250
28.	Superheater Co	250
29.	United States Steel Corp	750
30.	Carpenter Steel Co	100
31.	Utilities Coordinated Research, Inc[a]	3000
32.	Republic Steel Corp	500
33.	Walworth Co	300
34.	Calorizing Co	200
	Total	$16,800

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[a] An organization that represents a large number of light and power companies.

High-Temperature Test Methods (Special Committee on Test Codes, N. L. Mochel, chairman):

This committee again reviewed the Tentative Method of Test for Short-Time High-Temperature Tension Tests of Metallic Materials (E 21 - 34 T), and the Tentative Method of Test for Long-Time (Creep) High-Temperature Tension Tests of Metallic Materials (E 22 - 35 T), at meetings held during the year.

It is recommended that these methods remain tentative although the committee has no changes to suggest at this time, pending procurement of the results of additional researches.

Committee III on Projects (C. E. MacQuigg, chairman):

Activities of subcommittees during the past 12 months may be summarized as follows:

Subcommittee D on Short-Time Tension Tests (H. J. Kerr, chairman).—Cooperative tests were undertaken at different laboratories under the Tentative Method of Test for Short-Time High Temperature Tension Tests (E 21 - 34 T) using as a "standard" sample, bars of 0.35 per cent carbon steel (K 20)[1] specially prepared by the Bethlehem Steel Co., Bethlehem, Pa., to provide uniformity in structure and properties.

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[1] A full description of this material is given in "Short-Time Tensile Tests at 850 F. of the 0.40 per cent Carbon Steel, Material K-20," Report of Subgroup D of Subcommittee 3, *Transactions*, Am. Soc. Mechanical **Engrs., February, 1936, pp. 97–101.**

A report giving the results of these tests was prepared and published during the year (see Committee IV on Publications). The short-time test method E 21 – 34 T may be considered generally satisfactory, although one or two precautionary notes may be required to take care of constant temperature as the test specimen stretches under the load and also to restrict somewhat the speeds of testing. Both of these items now are receiving attention.

A supply of the "standard" steel (K 20) used in these tests and the cooperative creep tests (referred to later) is stocked at the Battelle Memorial Institute, Columbus, Ohio. This is for use by interested laboratories or individuals on application to the chairman of Committee III on Projects and is subject only to the requirement that a full report on test results be submitted to the committee.

Subcommittee E on Long-Time Tension Tests (C. L. Clark, chairman).—C. L. Clark was appointed chairman of this subcommittee, succeeding M. S. Northup, resigned.

Cooperative creep tests were undertaken on steel K 20, operating under the Tentative Method E 22 – 35 T. Results obtained to date show that generally good agreement was secured in the results obtained at different laboratories. The agreement in creep rates is somewhat better than that in values of total deformation; further, the longer the tests were extended, the closer were the rates of creep.

Subcommittee N on Wear and Seizure (J. W. Bolton, chairman).—A report summarizing available information on the wear and seizure of metals at high temperatures was prepared and published during the year (see Committee IV on Publications).

Subcommittee O on Chemical Stability (Jerome Strauss, chairman).—Cooperative corrosion tests of austenitic steels, subsequent to exposure to elevated temperatures, were continued during the year, but are incomplete and it is not known whether publication will be warranted when the data are finally assembled.

Subcommittee P on Low Temperatures (H. W. Russell, chairman).—An effort is being made to secure detailed information on industrial problems involving metals at low temperatures. Initial summaries will be based on a questionnaire only recently distributed.

Eleven laboratories cooperated in low temperature impact tests on the 0.35 per cent carbon steel (K 20) prepared by the Bethlehem Steel Co., as a "standard" sample.

A preliminary summary of this work comprises Appendix I to this report and indicated that present methods are not sufficiently refined to insure close agreement at all test temperatures in notched bar impact tests made at different laboratories.

Sponsored Researches.—Researches sponsored by the committee at the

Battelle Memorial Institute continued during the past 12 months. A limited study was completed and a report published (see Committee IV on Publications) on the embrittlement of austenitic nickel-chromium steels resulting from long exposure to high temperatures, with and without stress.

As was pointed out last year, creep tests extending for periods of more than several thousand hours are not often made and yet design is frequently based on a service life of 20,000 to 100,000 hours. Estimates, even when based on creep tests of several thousand hours duration, are extrapolations and two years ago the committee undertook to correlate the results of creep tests made under the usual conditions with the creep observed under long-time exposures (3 yr.) to stress at high temperatures.

The long-time tests, now in their second year, are summarized in Appendix II to this report. They emphasize the fact that extrapolations, based on the assumption that the rate of creep determined at the end of a thousand hours or so will continue at that rate, may be misleading. They make evident that a thorough-going knowledge of the extent of the strain hardening temperature range of a material must be added to the usual creep data determined in or near that range before sound design figures can be set.

Committee IV on Publications (H. W. Gillett, chairman):

In addition to its usual activities involving the preparation of news items, reviews of committee reports, etc., Committee IV arranged for a special session at the annual meeting of the American Society of Mechanical Engineers, held in New York City, in December, 1935. It handled the editorial work, for the Joint Committee, in the publication of four reports, as follows:

"Cooperative Study of a Stable 18:8, Without Stabilizing Additions," *Transactions*, Am. Soc. Mechanical Engrs., February, 1936, pp. 115–116.

"Seizure of Metals at Elevated Temperatures and Methods of Testing for Propensity Toward Seizure," Report of Subgroup N on Wear and Seizure of Subcommittee 3, *Mechanical Engineering*, March, 1936, pp. 165–168.

"Short-Time Tensile Tests at 850 F. of the 0.40 per cent Carbon Steel, Material K-20," Report of Subgroup D of Subcommittee 3, *Transactions*, Am. Soc. Mechanical Engrs., February, 1936, pp. 97–101.

"Long-Time Creep Tests of 18 per cent Chromium, 8 per cent Nickel Steel and 0.40 per cent Carbon Steel," Report of Sponsored Researches at Battelle Memorial Institute, by H. C. Cross and F. B. Dahle, *Transactions*, Am. Soc. Mechanical Engrs., February, 1936, pp. 91–96.

In addition, the following paper was presented at the December meeting which was held under the sponsorship of the committee:

"High-Temperature Properties of Cast and Wrought Carbon Steels from Large Valves for High-Temperature Service," by H. C. Cross and F. B. Dahle, *Transactions*, Am. Soc. Mechanical Engrs., February, 1936, pp. 103–113.

Committee V on Oil Refinery Problems (H. J. French, acting chairman):

As reported last year, this group, representing the sponsors of the Joint Committee, the American Petroleum Institute and the American Association of Steel Manufacturers, was not able to develop an acceptable plan for joint attack on problems relating to oil refinery metals.

In view of the relatively rapid changes in practice and the wide diversity of problems in different refineries, it was believed to be desirable to suspend activities of this committee for the past year. Should the situation warrant this committee will be called upon to formulate new plans at a later date.

Miscellaneous Activities:

The Joint Committee and its individual members maintained contact and cooperated with other committees or organizations, including A.S.T.M. Committee B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys; Subcommittee XXII on Valves, Fittings, Piping and Flanges for High-Temperature Service of A.S.T.M. Committee A-1 on Steel; and the Special Subcommittee on Ferrous Metals of the Boiler Code Committee of the American Society of Mechanical Engineers.

Future Work:

During the past few years, as is shown by its annual reports and other publications, the committee has concentrated activities upon creep in ferrous metals, with the idea of arriving at a better understanding of such phenomena in ferritic and austenitic steels. Test codes also have been prepared and kept up to date with the object of providing industry with a much needed standard of creep testing technique which is an important factor in determining allowable stresses for high-temperature service.

The committee, subject to the procurement of adequate financial support, plans to continue to develop information relating to creep in metals, but it is not unmindful of the fact that creep is but one of many factors which deserve detailed attention in considering metals for both high- and low-temperature service. In future work, the committee plans to initiate or sponsor work relating to other important properties—both with respect to elevated and subzero degrees Fahrenheit temperature service.

Details are now under discussion and it is hoped that the new work will help better to serve the needs of industry by providing a broader basis upon which to assign allowable working stresses.

Respectfully submitted on behalf of the Joint Committee,

H. J. FRENCH,
Chairman.

N. L. MOCHEL,
Secretary.

APPENDIX I

GENERAL SUMMARY AND COMPARISON OF PROCEDURE AND RESULTS OBTAINED ON COOPERATIVE STUDY OF LOW-TEMPERATURE IMPACT TESTING OF 0.35 PER CENT CARBON STEEL (K20)

SUMMARIZED FOR SUBCOMMITTEE P FROM THE REPORTS OF ELEVEN LABORATORIES

BY R. SERGESON AND S. W. POOLE

In order to get basic information on the low-temperature impact test as it is now being conducted, the members of Subcommittee P of Committee III on Projects, of the Joint A.S.M.E.–A.S.T.M. Research Committee on Effect of Temperature on the Properties of Metals, cooperated in making such tests.

Material:

The material selected for these tests was the 0.35 per cent carbon steel known as K20 provided for the use of the main committee through the courtesy of Mr. P. E. McKinney of the Bethlehem Steel Co. This steel is being used in several projects of the main committee and its subcommittees. Details of the manufacture and annealing of K20 steel are given in a previous committee report.[1]

Complete analysis of the heat of steel of which the K20 steel is a product shows the following composition:

Carbon, per cent	0.35
Manganese, per cent	0.55
Sulfur, per cent	0.03
Phosphorus, per cent	0.016
Silicon, per cent	0.19

The physical properties of this steel are as follows:

Tensile strength, lb. per sq. in	69,000
Elongation in 2 in., per cent	38
Reduction of area, per cent	65.8
Brinell hardness number	131

Test Temperatures:

The low-temperature impact tests were conducted at temperatures of 70, 25, 0, −25, and −50 F. Several laboratories tested this steel at temperatures below −50 F. The procedure used in obtaining low temperatures consisted in cooling the specimens in liquid, a bath usually of methyl or ethyl alcohol, acetone or a mixture of acetone and chloroform, with solid carbon dioxide (dry ice) as the refrigerant. The specimens were held from 15 to 45 min. at the temperature and tested within 2 to 5 sec.

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[1] Short-Time Tensile Tests at 850 F. of the 0.35 Per Cent Carbon Steel Material K20. Progress report by Subgroup D. *Transactions*, Am. Soc. Mechanical Engrs., Vol. 58, No. 2, February, 1936, p. 97.

Test Specimens:

Each laboratory prepared its own test specimens and the following types of impact specimens were used:

(*a*) *Charpy V-Notch Specimens* were 0.394 in. (10 mm.) square and 2.165 in. long, with a standard 45-deg. notch 0.079 in. in depth with a base radius of 0.01 in.

(*b*) *Charpy Keyhole-Notch Specimens* were 0.394 in. (10 mm.) square and 2.165 in. long and the notch was made by drilling a hole with a No. 47 drill, the center of the hole being 0.160 in. from the edge, and then slotting the specimen from the hole to this edge.

(*c*) *Izod V-Notch Specimens* were 0.394 in. (10 mm.) square with the Charpy V-Notch 1.102 in. from the end.

(*d*) *Izod Keyhole-Notch Specimens* had a notch similar to the Charpy specimen, that is, a drilled hole (No. 47 drill) slotted to the specimen edge, the distance from the center of the hole to the edge being 0.160 in. The cross-sectional dimensions of the keyhole specimen are similar to those of the V-notched type, that is, 0.394 in. square with an effective cross-sectional area at the point of failure of 0.077 sq. in.

(*e*) *Tension-Impact Specimens.*—Low-temperature tension-impact tests conducted by one of the cooperators used two types of notched tension-impact specimens. Both types were 3 in. in length, but in one case the notch was 1.0 in. and in the other, 0.1 in. The diameter at the base of the notch in both cases was 0.252 in. The depth of the notch was 0.298 in.

Testing Machines:

Information on the construction of different types of available impact testing machines are given in the following table.[1] The types of impact testing machines used by the cooperating laboratories are noted on the summarized impact testing data curves.

NAME OF MACHINE	CHARPY	IZOD	COMBINED CHARPY	COMBINED IZOD
Weight of pendulum at point of impact, lb	46.78	60	54.55	60
Height of fall of impact point, ft	4.8	2	4.4	2
Distance from axis of suspension to the center of impact on test piece, in	29.72	48	35.43	35.43
Velocity of striking edge at impact, ft. per sec	17.54	11.35	16.82	11.35
Total energy, ft-lb	224	120	240	120
Striking distance above vise, in	......	0.866	......	.....
Striking position on specimen, 40-mm. span	center of specimen	.....	center of specimen	.....
Weight of machine, lb	550	1400	1400	1400

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[1] The courtesy of Mr. R. B. Lewis of The Tinius Olsen Testing Machine Co. in assembling this table is gratefully acknowledged.

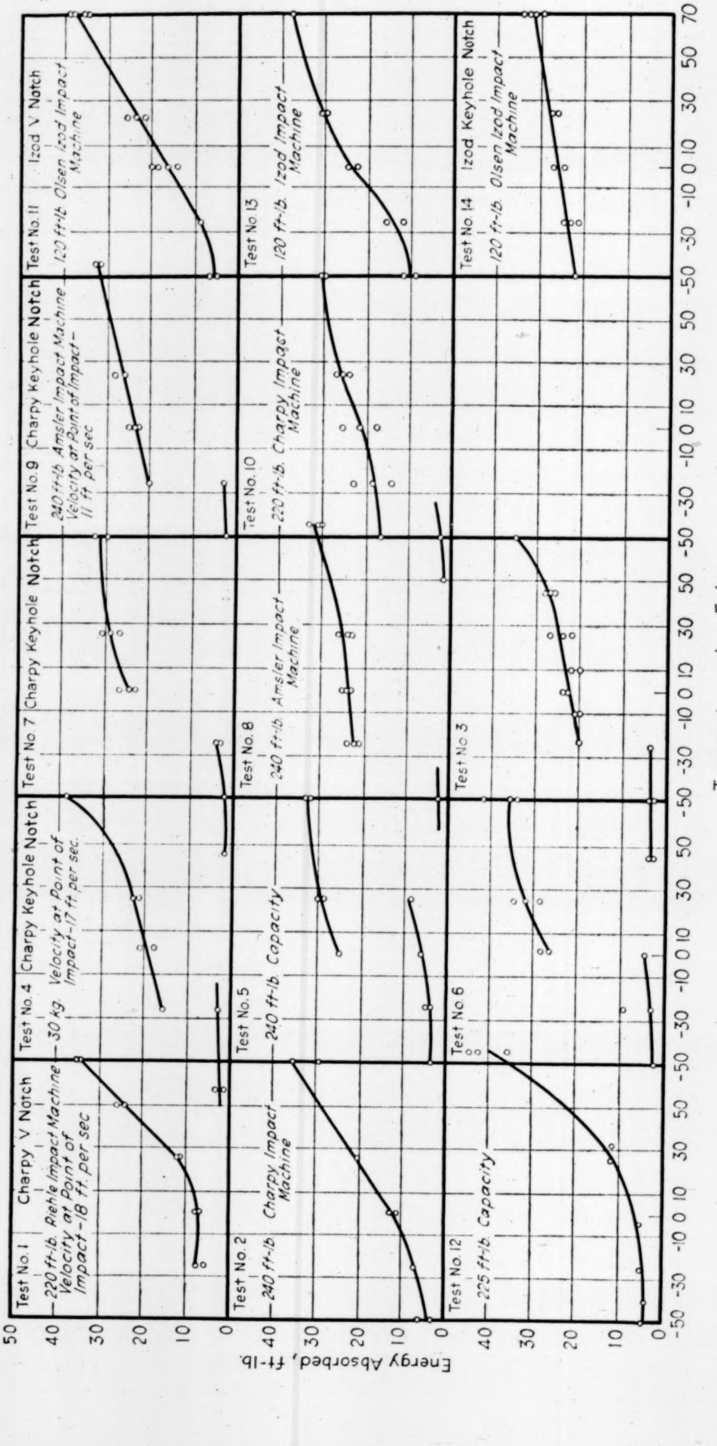

FIG. 1.—Graphical Summary of Data Submitted by the Eleven Cooperating Laboratories.

In five cases where tests were made below −50 F. the low branch of the curve is extended into the adjacent plot to save space. It should be noted that the temperature scale for these extensions is not shown. In these cases, +50 F. on the adjacent plot is really −70 F.

Results:

The test results are shown in Fig. 1. Numbers have been assigned to the separate tests for convenience of reference.

Charpy V-Notch.—Tests Nos. 1, 2 and 12 show a continuous decrease in impact value with decreasing temperature, extending from about 35 ft-lb. at 70 F. to 5 ft-lb. at −25 F. The greatest difference between the tests is at +25 F. where the values are 10 and 20 ft-lb.

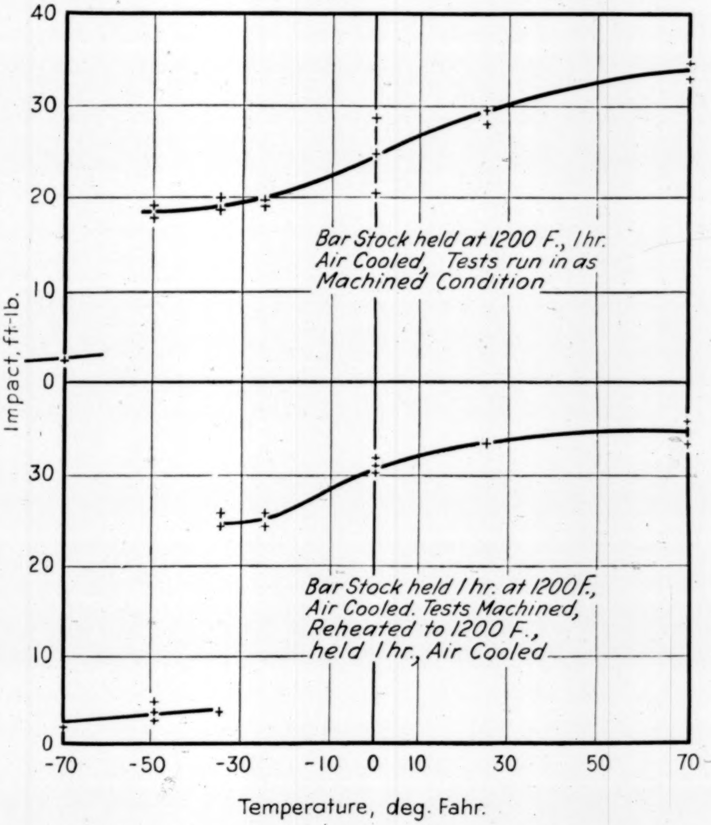

FIG. 2.—Low-Temperature Impact Data on Steel K20.
Steel in the as-machined and drawn condition.

Charpy Keyhole Notch.—These tests are characterized in every case by an abrupt drop in the impact value with decreasing temperature. Tests Nos. 3, 4, 5, 6, 9 and 10 show two distinct impact values at the same temperature. Test No. 5 shows two values at both +25 F. and 0 F. In all tests there is a gap of at least 13 ft-lb. within which no impact values are recorded. Except for tests Nos. 4 and 10 there are no values between 10 and 20 ft-lb. The conclusion is inescapable that the Charpy keyhole impact *versus* temperature curve consists of two branches which cannot be joined, but which may overlap in temperature. Such an effect has been reported previously. There is moderately good agreement on a value of about 32 ft-lb. at +70 F. and of about 3 ft-lb. at −50 F. The "critical temperature" at which the material first acts brittle is in the range from +25 F. in test No. 5 to something below −25 F. in test No. 8.

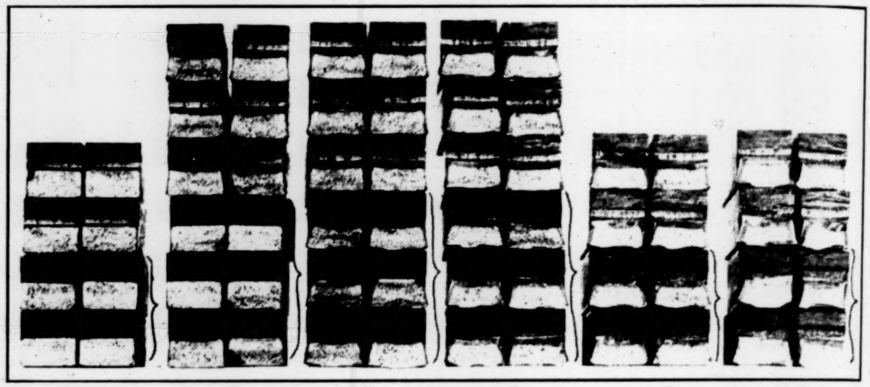

FIG. 3.—Charpy Fractures Obtained at the Various Temperatures.

The lower sets of fractures (bracketed) represent the tests which were reheated to 1200 F. and air cooled after machining.

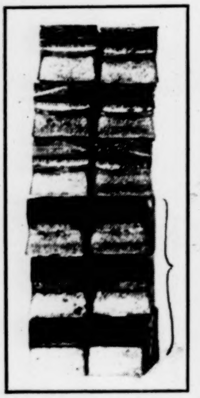

FIG. 4.—Charpy Fractures Obtained at −35 F.

The lower three sets represent the material redrawn at 1200 F.

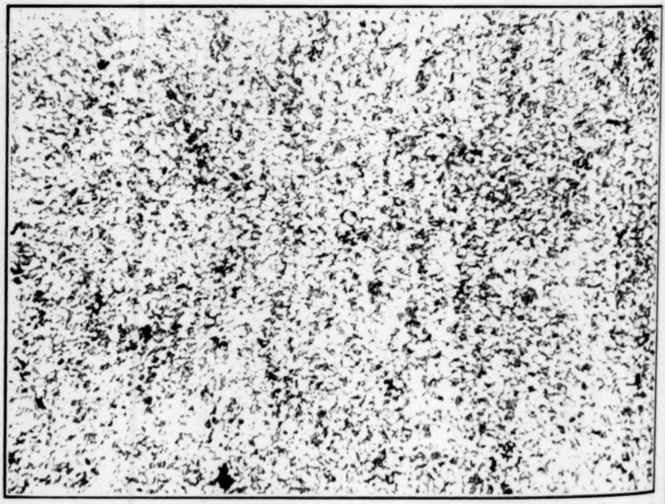

FIG. 5.—Typical Microstructure of K20 Steel (× 100).

Izod V-Notch.—Tests Nos. 11 and 13 show agreement at 70 F. with a value of about 38 ft-lb., dropping uniformly with moderate agreement and ending at 6 and 10 ft-lb., respectively at −50 F. These are higher values than given by the previous tests.

Izod Keyhole Notch.—Test No. 14 starts at +70 F. with 32 ft-lb. in agreement with the Charpy keyhole specimens, but it drops only slightly, ending at −50 F. on the relatively high value of 22 ft-lb. Possibly at some lower temperature an abrupt drop may develop.

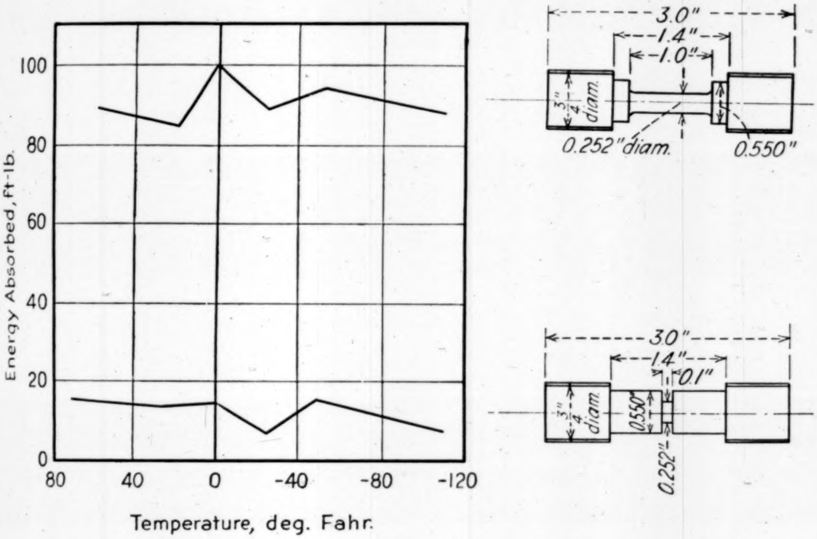

FIG. 6.—Notched Tension-Impact Tests with Relation to Temperature.

Chemical Composition:	
Carbon, per cent	0.37
Manganese, per cent	0.53
Phosphorus, per cent	0.016
Sulfur, per cent	0.021
Silicon, per cent	0.17
Nickel, per cent	0.07
Chromium, per cent	0.10

Heat Treatment:
1550 F. for 1 hr., furnace cooled to 1000 F., then air cooled.
1280 F. for 2 hr., furnace cooled to 1000 F., then air cooled.

Discussion:

In any one test, the difference between any two impact values at a given temperature never exceeded 6 ft-lb. (except at "critical temperatures") and the maximum deviation from the average value at a given temperature seldom exceeds 2 ft-lb. This indicates good reproducibility of the testing technique and of the material being tested. While, at first sight, the various tests are extremely discordant, the situation is not entirely hopeless. In each separate type of test there is agreement as to the manner in which the steel is affected by low temperature. But it must be admitted that it would be difficult to predict the temperature at which this steel would be unfit for service.

STUDIES OF REDRAWN SPECIMENS

At the meeting of Subcommittee P held on March 5, 1936, the question was raised as to whether the material had been fully annealed. At that time it was suggested that tests be made on material which had been redrawn at 1200 F. and air cooled. Half of the test specimens machined from this redrawn stock were to be drawn again at 1200 F. and the tests at low temperatures repeated. Since this meeting, however, the record of one complete treatment of the K20 steel has shown it to be in the fully annealed condition as supplied.

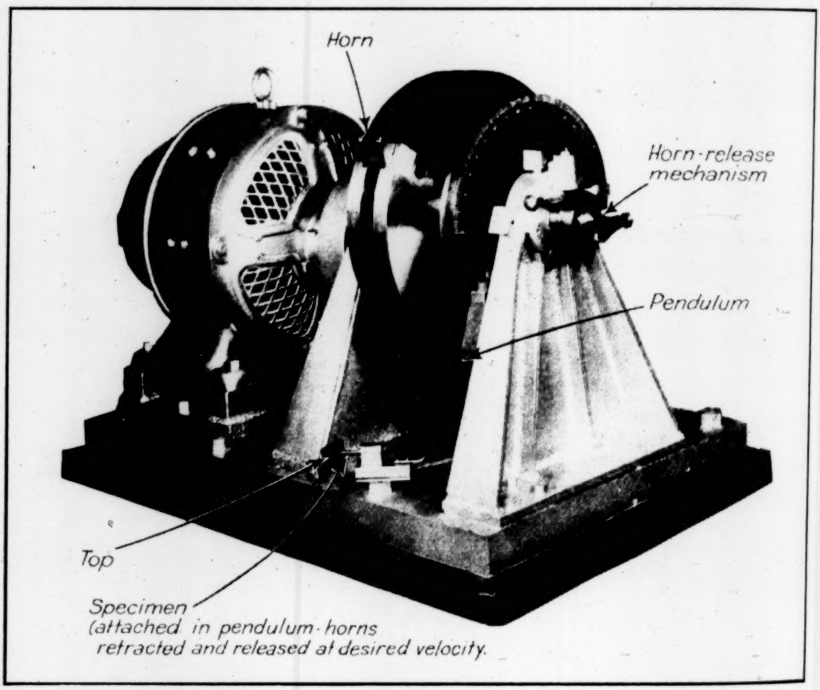
Horn
Horn-release mechanism
Pendulum
Top
Specimen (attached in pendulum-horns retracted and released at desired velocity.

FIG. 7.—Tension-Impact Testing Machine Used by One of the Cooperating Laboratories to Determine Energy Absorbed in Relation to Velocity of Impact.

The work on redrawn specimens was done at the metallurgical laboratory of the Republic Steel Co. The procedure was as follows:

A sufficient quantity of the as-received 1-in. round bar stock to provide specimens for 30 impact tests was held at 1200 F. for 1 hr. and air cooled. Standard Charpy keyhole-notch test specimens 0.394 in. square and 2.165 in. long were machined from this stock. Half of the machined impact test specimens were reheated to 1200 F., held at this temperature for 1 hr., and air cooled.

Impact tests were made on the as-machined specimens and the redrawn (1200 F. for 1 hr.) specimens at the following temperatures: 70, 25, 0, −25, −35, −50 and −70 F. The low temperatures were obtained by adding solid carbon dioxide to methyl alcohol in a large thermos container. The impact test specimens were placed in a small perforated

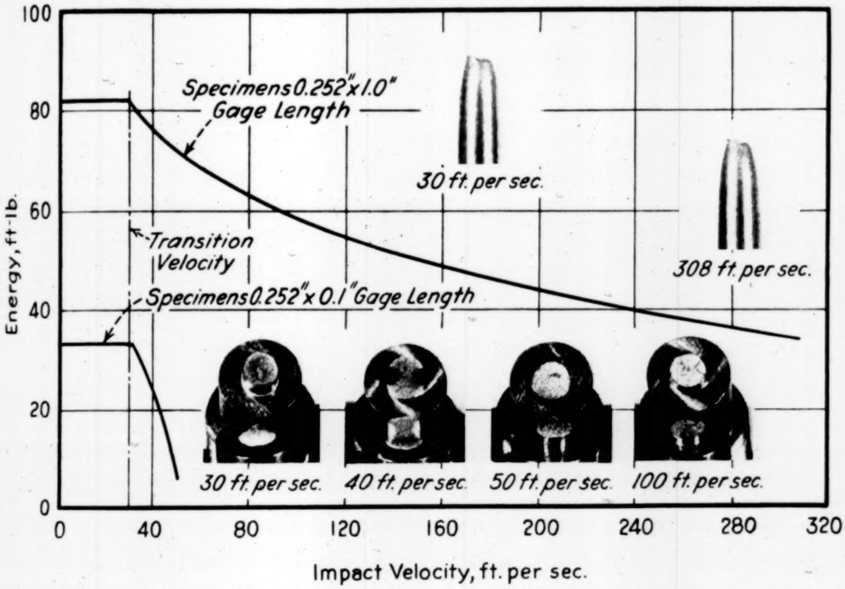

FIG. 8.—Notched Tension-Impact Tests Showing Energy Absorbed with Relation to Impact Velocity.

TABLE I.—LOW-TEMPERATURE IMPACT TEST DATA ON REDRAWN SPECIMENS.

	AS-MACHINED SPECIMENS		SPECIMENS REDRAWN AT 1200 F. FOR 1 HR.	
TEST TEMPERATURE	ENERGY ABSORBED, FT-LB.	FRACTURE	ENERGY ABSORBED, FT-LB.	FRACTURE
−70 F	2.1	Brittle	2.5	Brittle
−70 F	2.1	Brittle	2.9	Brittle
−50 F	19.2	Ductile	2.9	Brittle
−50 F	19.2	Ductile	3.3	Brittle
−50 F	18.0	Ductile	4.5	Brittle
−35 F	18.6	Ductile	3.7	Brittle
−35 F	19.2	Ductile	25.9	Ductile
−35 F	19.9	Ductile	24.4	Ductile
−25 F	19.2	Ductile	25.9	Ductile
−25 F	19.9	Ductile	25.9	Ductile
−25 F	19.2	Ductile	24.4	Ductile
0 F	28.8	Ductile	30.2	Ductile
0 F	24.4	Ductile	31.8	Ductile
0 F	20.5	Ductile	31.0	Ductile
+25 F	25.9	Ductile	33.5	Ductile
+25 F	24.4	Ductile	33.5	Ductile
+70 F	25.9	Ductile	33.5	Ductile
+70 F	33.5	Ductile	35.9	Ductile
+70 F	35.0	Ductile		

sheet-iron bucket which was kept immersed in the cooling medium. The specimens were held at the test temperature for 20 min. before breaking. The specimens tested at −70 F. were broken first and the specimens to be broken at the higher temperatures, −50, −35, −25, 0, and +25 F., were successively placed in the perforated bucket during the rise in temperature of the cooling mixture on standing.

The data obtained are shown in Table I. These data have been plotted and the curves obtained are shown in Fig. 2. Photographs of the fractures obtained are shown in Figs. 3 and 4. A typical photomicrograph showing the structure of K20 steel appears in Fig. 5.

A study of the low-temperature impact test data obtained on the redrawn specimens indicates the following:

(*a*) Consistently higher values were obtained on the impact test specimens reheated to 1200 F., held 1 hr. and air cooled after machining, except at very low temperatures, −50 and −70 F.

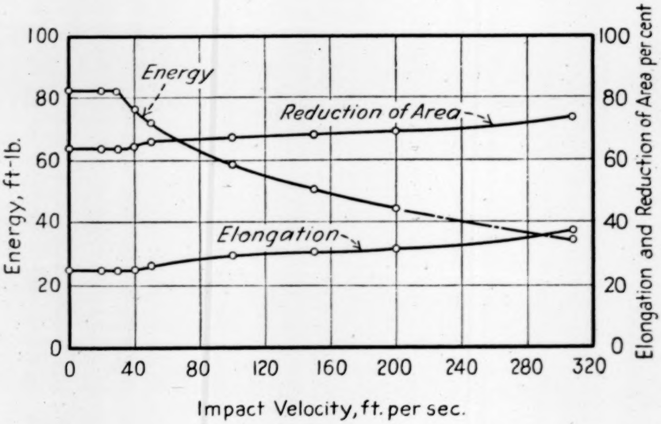

FIG. 9.—Impact Velocity in Relation to Elongation, Reduction of Area and Energy.

Chemical Composition:

Carbon, per cent	0.37
Manganese, per cent	0.53
Phosphorus, per cent	0.016
Sulfur, per cent	0.021
Silicon, per cent	0.170
Nickel, per cent	0.07
Chromium, per cent	0.10

Heat Treatment:

1550 F., for 1 hr., furnace cooled to 1000 F., then air cooled.

1280 F., for 2 hr., furnace cooled to 1000 F., then air cooled.

(*b*) There was a general tendency for the impact values obtained on the redrawn test specimens to be more consistent than the values obtained on the as-machined specimens.

(*c*) There is marked difference between the two curves in that the curve for the as-machined specimens shows all impact values to range from 18.0 to 35.0 ft-lb. for the temperature range −50 F. to +70 F. The curve for the redrawn specimens show very low values (2.5 to 4.5 ft-lb. characterized by a brittle fracture for −70 F., −50 F., and one for −35 F. From −35 to +70 F. the impact values range from 24.4 to 35.9 ft-lb.

The curve for the tests on redrawn specimens then shows up to a greater degree the peculiar nature of the impact-temperature curve for this steel which is evidently formed by two definite branches overlapping in temperature.

(*d*) Microexamination at high magnification (×1000) showed that the brittle fractures which gave very low impact values (2.5 to 5.0 ft-lb.) had fractured along the grain boundaries. The ductile type of fracture which gave impact values of 18.0 to 35.9 ft-lb. were observed to have fractured through the grains.

EFFECT OF IMPACT VELOCITY ON ENERGY ABSORBED WITH NOTCHED TENSION-IMPACT SPECIMENS FROM STEEL K20

The discussion and results from a report from Watertown Arsenal concerned with the effect of velocity of impact with relation to energy absorbed using notched tension-impact specimens from steel K20 are given below.

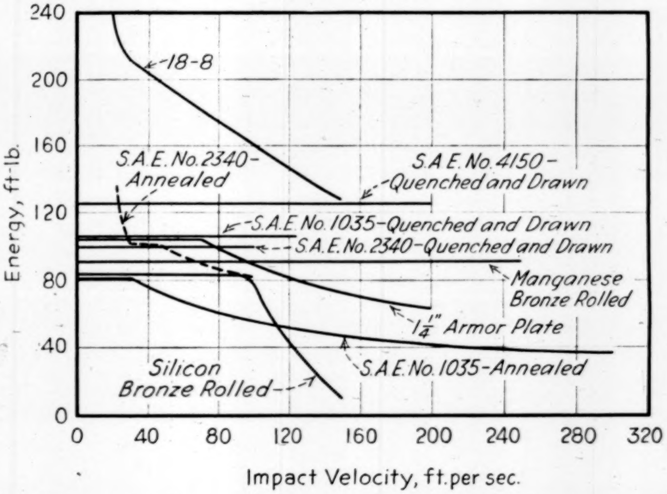

FIG. 10.—Tension-Impact Tests on Several Ferrous and Non-Ferrous Metals Showing Relation Between Energy Absorbed and Impact Velocity.
Specimens 0.252 in. × 1.0-in. gage.

Low-Temperature Tension-Impact Tests:

Low-temperature tension-impact tests on specimens having notches of 1.0 in. and 0.1 in., respectively, were made on a large Charpy impact machine (capacity 2160 ft-lb.). The specimens were brought to the low temperatures in the machine by means of acetone and solid carbon dioxide, being held at the test temperature for 20 min. before breaking. Results are shown in Fig. 6.

High-Velocity Tension-Impact Tests:

The high-velocity tension-impact tests were made on a special machine designed and built at the Watertown Arsenal, a photograph of which is shown in Fig. 7. Specimens having notches of 1.0 in. and 0.1 in. in length respectively, were tested and the results are shown in Figs. 6, 8 and 9. It is of interest to note that in the K20 material, up to a velocity value of 30 ft. per sec., the energy and ductility values are constant; above this so-called transition velocity, however, in the case of the 1.0-in. notch specimens, the energy decreases and the ductility increases. With the 0.1-in. notch, both energy and ductility decrease. Microscopic studies of the 1.0-in. notch specimens at the point of fracture show that the fracture occurs around the grains up to the transition velocity (30 ft. per sec.) and as the velocity is increased the fracture is straight across the grains. With further increase in velocity it assumes 45 deg. forms through the grains.

Several other materials have been tested including a few of the bronzes and this so-called transition velocity is found to change with the material and heat treatment. A similar material (S. A. E. No. 1035) quenched and drawn shows no change, even at a velocity of 125 ft. per sec. Curves showing this are given in Fig. 10. In view of the transition phenomena disclosed by the high-velocity tests, Watertown Arsenal is investigating the effect of different notch lengths as well as the velocity effect in the shear type of failure.

APPENDIX II

REPORT ON LONG-TIME CREEP TESTS OF 18 PER CENT CHROMIUM, 8 PER CENT NICKEL STEEL AND 0.35 PER CENT CARBON STEEL

REPORT TO THE JOINT COMMITTEE COVERING A SPONSORED RESEARCH PROJECT CARRIED OUT AT BATTELLE MEMORIAL INSTITUTE.

SYNOPSIS

Long-time creep test data are reported for an 18 per cent chromium, 8 per cent nickel steel tested at 1200 F. and a 0.35 per cent carbon steel tested at 850 F.

Two 18 per cent chromium, 8 per cent nickel steel specimens have been under test for 10,125 and 11,680 hr. at a load of 8345 lb. per sq. in. at 1200 F.

Two 0.35 per cent carbon-steel specimens have been under test at 850 F. for 9620 and 8690 hr. at loads of 8000 and 7500 lb. per sq. in., respectively.

Linear extrapolations to 10,000 hr. at rates of creep obtained during the period from 1000 to 2000 hr. would be conservative for the 0.35 per cent carbon steel but misleading for the 18 per cent chromium, 8 per cent nickel steel at these loads and temperatures.

This report is a continuation of the progress report on the same long-time creep tests presented before The American Society of Mechanical Engineers in December, 1935.[1]

This program was undertaken to procure data for comparisons of creep rates obtained over short and long periods of time. These data will permit comparisons of values obtained by extrapolations and computations from creep tests of short periods of time with the actual test data obtained over longer test periods.

Two of the tests have been discontinued at about 10,000 hr. It is planned to continue some of the tests to approximately 25,000 hr.

MATERIAL AND TEST EQUIPMENT

The 18 per cent chromium, 8 per cent nickel steel was water quenched from 2000 F. prior to test while the 0.35 per cent carbon steel was supplied full annealed.

Details of the preparation, heat treatment and properties of the 18 per cent chromium, 8 per cent nickel steel and the 0.35 per cent carbon steel are given in previous progress reports to the A.S.M.E.-A.S.T.M.

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[1] H. C. Cross and F. B. Dahle, "Long-Time Creep Tests of 18 Cr 8 Ni Steel and 0.35 per cent Carbon Steel," Progress Report of the A.S.M.E.-A.S.T.M. Joint Research Committee on Effect of Temperature on the Properties of Metals, *Transactions*, Am. Soc. Mechanical Engrs., Vol. 58, No. 2, (1936), p. 91 (RP-58-3).

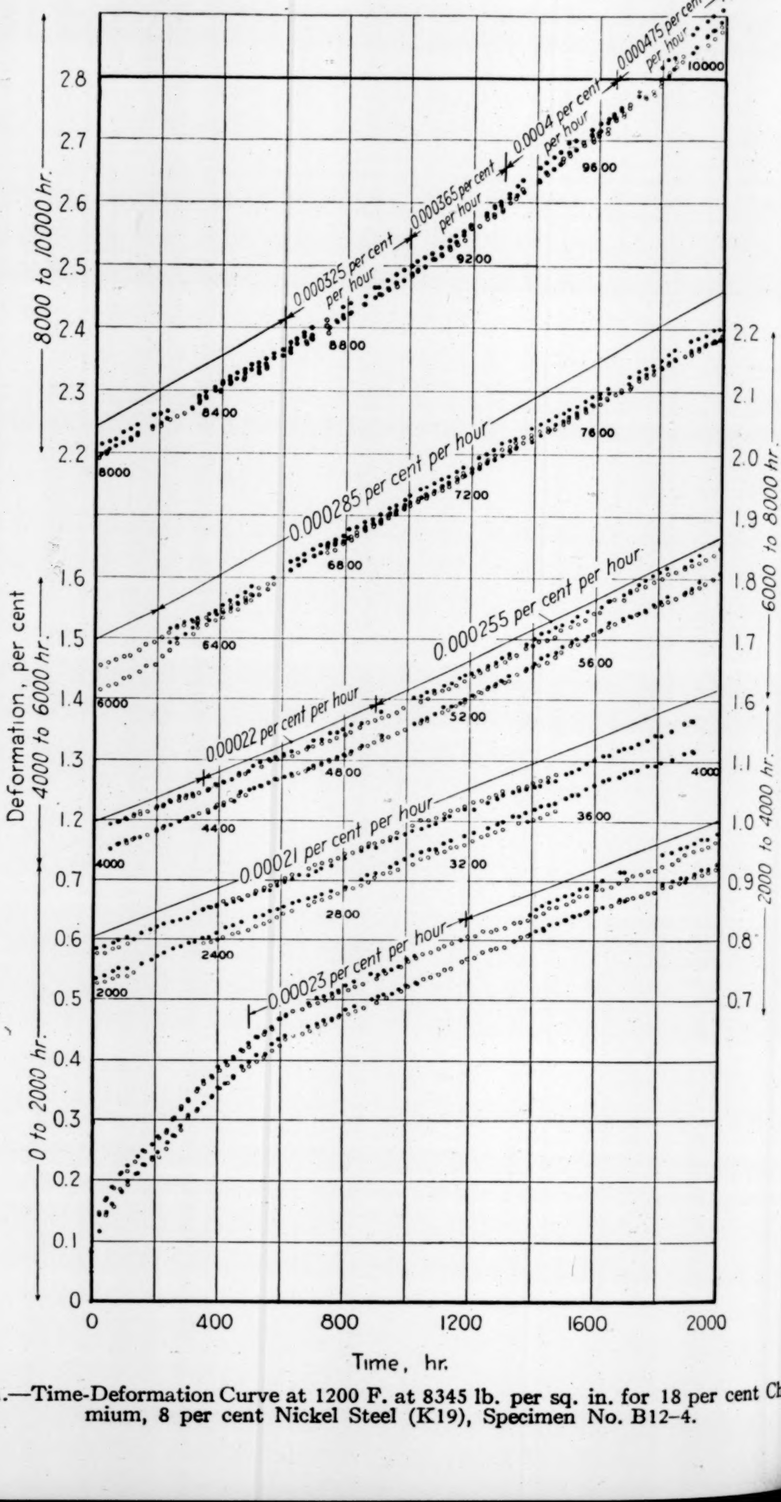

FIG. 1.—Time-Deformation Curve at 1200 F. at 8345 lb. per sq. in. for 18 per cent Chromium, 8 per cent Nickel Steel (K19), Specimen No. B12-4.

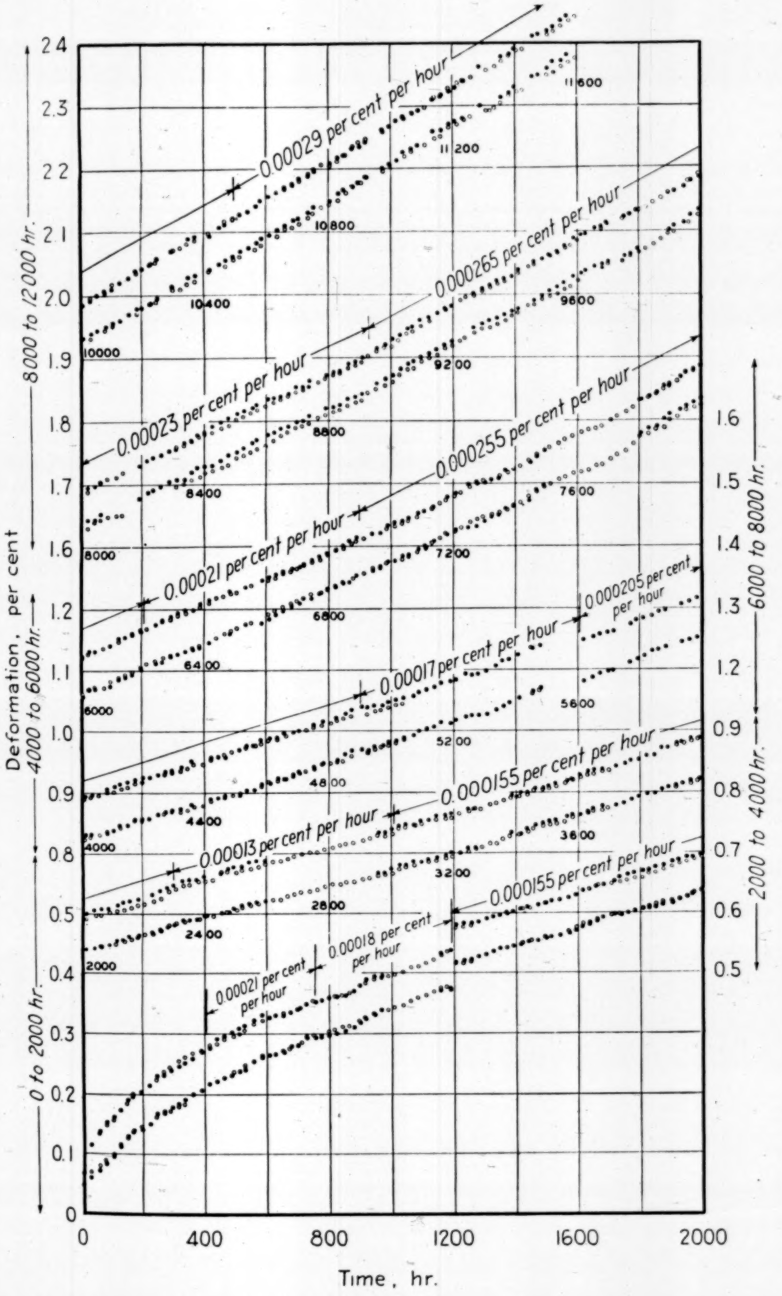

FIG. 2.—Time-Deformation Curve at 1200 F. at 8345 lb. per sq. in. for 18 per cent Chromium, 8 per cent Nickel Steel (K19), Specimen No. B12-1.

Joint Research Committee on Effect of Temperature on the Properties of Metals.[1,2]

Creep Tests on 18 per cent Chromium, 8 per cent Nickel Steel (K19):

The time-deformation curves for the 18 per cent chromium, 8 per cent nickel steel at 1200 F. at 8345 lb. sq. in. are shown in Figs. 1 and 2. Table I gives a summary of their creep test data.

The test on specimen No. B12-4 has been discontinued at 10,127 hr. The rate of deformation was increasing rapidly over the last 2500 hr. and between 9675 and 10,127 hr. was at a rate of 0.000475 per cent per hr.

TABLE I.—CREEP TEST DATA FOR 18 PER CENT CHROMIUM, 8 PER CENT NICKEL STEEL (K19).

Test Temperature 1200 F.; Load 8345 lb. per sq. in.

Specimen	No. B38-2		No. B12-1		No. B12-2		No. B12-4	
Initial Deformation, per cent	0.21		0.06		0.07		0.06	
Duration of Test, hr	1655		11 257		1008		9693	
	Rate of Deformation, per cent per hr.	Total Deformation, per cent	Rate of Deformation, per cent per hr.	Total Deformation, per cent	Rate of Deformation, per cent per hr.	Total Deformation, per cent	Rate of Deformation, per cent per hr.	Total Deformation, per cent
500 hr	0.00016	0.435	0.00021	0.27	0.00056	0.45	0.00043	0.41
1 000 hr	0.00016	0.51	0.00018	0.36	0.00045	0.69[a]	0.00023	0.54
1 600 hr	0.000122	0.60[a]	0.000155	0.50	....	....	0.00021	0.67
2 000 hr	....	....	0.000155	0.57	....	....	0.00021	0.75
3 000 hr	....	....	0.00013	0.70	....	....	0.00021	0.96
4 000 hr	....	....	0.000155	0.86	....	....	0.00021	1.16
5 000 hr	....	....	0.00017	1.01	....	....	0.000255	1.45
6 000 hr	....	....	0.000205	1.19	....	....	0.000255	1.63
7 000 hr	....	....	0.00021	1.40	....	....	0.000285	1.92
8 000 hr	....	....	0.000255	1.66	....	....	0.00028	2.19
9 000 hr	....	....	0.000265	1.89	....	....	0.000365	2.49
10 000 hr	....	....	0.00026	2.11	....	....	....	....
11 000 hr	....	....	0.00029	2.44[b]	....	....	....	....

[a] Test discontinued.
[b] Test continuing, rate of deformation 0.00029 per cent per hr. and total deformation 2.636 per cent at 11,675 hr.
[c] Test discontinued, rate of deformation 0.000475 per cent per hr. and total deformation 2.962 per cent at 10,127 hr.

The total deformation was about 2.962 per cent. The specimen temperature is being maintained after removal of the load for determining the magnitude of elastic recovery, if any. It is planned to replace this test specimen with another 18 per cent chromium, 8 per cent nickel steel specimen loaded to 5000 lb. per sq. in. at 1200 F. and to be tested for a period of 25,000 hr.

The test on specimen No. B12-1 has now progressed to 11,675 hr. with a total deformation of about 2.636 per cent. This test has shown an increased rate since about 9000 hr. but over the last 1100 hr. the rate has been nearly constant at about 0.00029 per cent per hr. It is planned to continue this test indefinitely.

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[1] H. C. Cross, "High-Temperature Tensile, Creep, and Fatigue of Cast and Wrought High-and-Low Carbon 18 Cr 8 Ni Steel from Split Heats," *Transactions*, Am. Soc. Mechanical Engrs., Vol. 56 (1934), p. 533 (RP-56-6).

[2] Short-Time Tensile Tests at 850 F. of the 0.35 per cent Carbon Steel Material K20, *Transactions*, Am. Soc. Mechanical Engrs., Vol. 58, No. 2 (1936), p. 97 (RP-58-4).

For greater ease of comparison, averages of the readings of two observers on the two sides of the specimens have been plotted as single time-deformation curves which are shown in Fig. 3.

The difference between the actual values of deformation resulting at 10,000 hr. as compared with the values that would be obtained by extrapolation from the more common test periods of from 1000 to 2000 hr. should be noted. For 18 per cent chromium, 8 per cent nickel steel at 8345 lb. per sq. in. at 1200 F., such extrapolation from short test periods would be misleading.

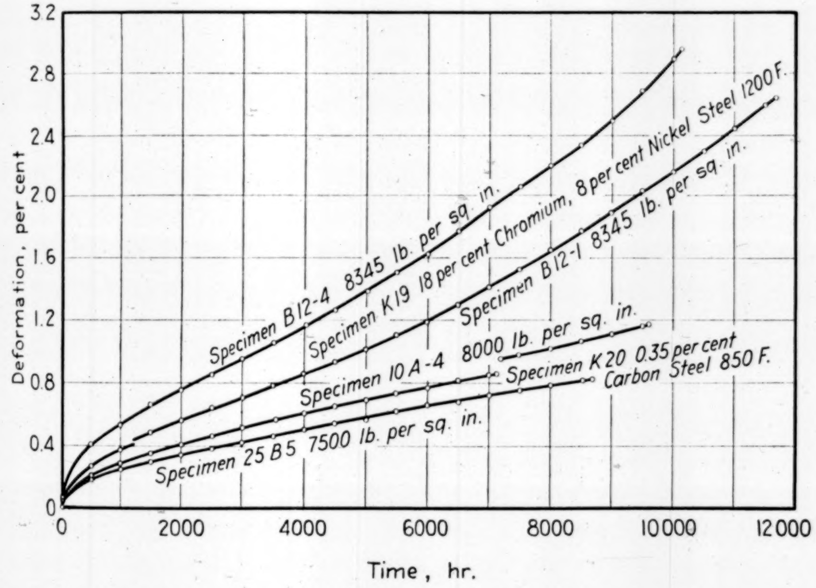


FIG. 3.—Time-Deformation Curves at 1200 F. for 18 per cent Chromium, 8 per cent Nickel Steel (K19) and at 850 F. for 0.35 per cent Carbon Steel (K20).

Creep Tests on 0.35 per cent Carbon Steel (K20):

The time-deformation curves for the 0.35 per cent carbon steel at 850 F. are shown in Figs. 4 and 5. Table II gives a summary of their creep test data.

The test on specimen No. 25B-5 at 7500 lb. per sq. in. has now progressed to 8700 hr. Since the decrease in rate of deformation between 4800 and 5200 hr., the rate has remained fairly constant and is now at 0.00006 per cent per hr. with a total deformation of 0.819 per cent. It is planned to continue this test to about 25,000 hr.

The test on specimen No. 10A-4 at 8000 lb. per sq. in. has been discontinued at 9617 hr. by removal of the load, but the temperature is being maintained, and as for specimen No. B12-4 determinations of elastic recovery are being made. From about 5000 to 7125 hr. the rate of deformation was about 0.000075 per cent per hr. At 7125 hr. a controller failure allowed the temperature to rise to 1030 F., an increase of 180 F. over the test temperature. When this trouble was found, the temperature was reduced to 850 F. and the test continued. During this short period of excessive temperature, deformation of about 0.1 per cent resulted as may be seen in Figs. 3 and 5. The rate of deformation since 7200 hr. has been slightly greater and showed a tendency to increase further. Since the last heat treatment on this steel was at 1280 F., a short sojourn at 1030 F. would not be expected to produce much, if any, change in structure or creep properties. The rate of deformation when the test was discontinued at 9617 hr. was at 0.000095 per cent per hr. with a total deformation of 1.07 per cent.

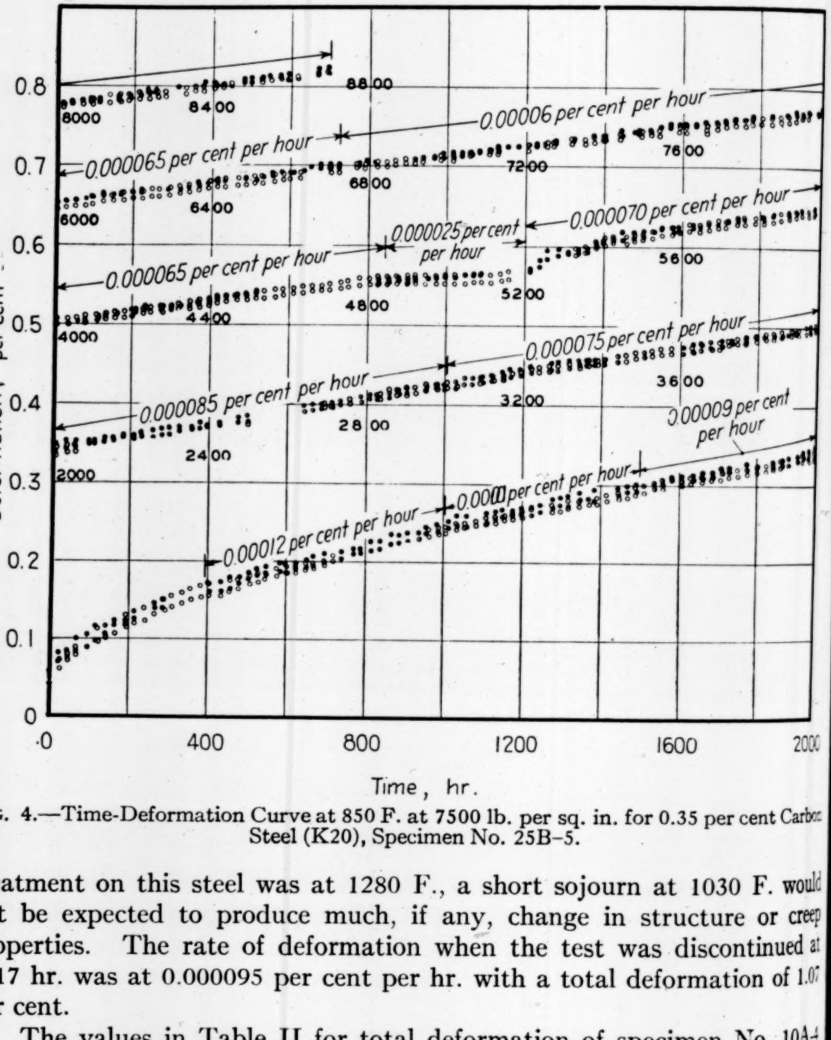
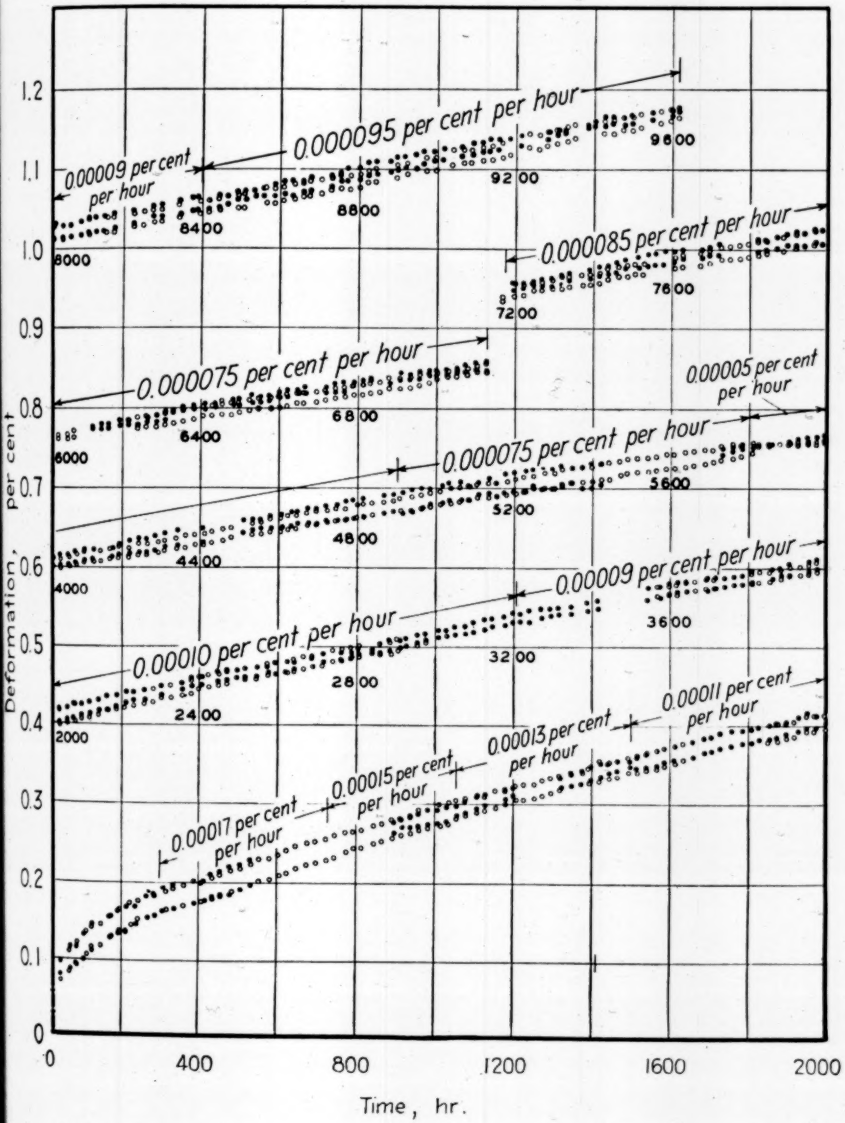


FIG. 4.—Time-Deformation Curve at 850 F. at 7500 lb. per sq. in. for 0.35 per cent Carbon Steel (K20), Specimen No. 25B-5.

The values in Table II for total deformation of specimen No. 10A-4 subsequent to 7125 hr. are corrected to take into account the extra 0.1 per cent deformation resulting from the controller failure.



IG. 5.—Time-Deformation Curve at 850 F. at 8000 lb. per sq. in. for 0.35 per cent Carbon Steel (K20), Specimen No. 10A–4.

As these tests on the 0.35 per cent carbon steel approach 10,000 hr. it may be seen that since noticeable strain-hardening has resulted extrapolations from the more common test periods of from 1000 to 2000 hr. would, at the loads and temperatures used, be on the conservative side.

TABLE II.—CREEP TEST DATA FOR 0.35 PER CENT CARBON STEEL (K20).

Test Temperature 850 F.

Specimen	No. 10A-1		No. 10A-3		No. 10A-4		No. 25B-5	
Load, lb. per sq. in.	10 000		9000		8000		7500	
Duration of Test, hr.	1030		1440		9183		8279	
Initial Deformation, per cent	0.05		0.05		0.04		0.05	
	Rate of Deformation, per cent per hr.	Total Deformation, per cent	Rate of Deformation, per cent per hr.	Total Deformation, per cent	Rate of Deformation, per cent per hr.	Total Deformation, per cent	Rate of Deformation, per cent per hr.	Total Deformation, per cent
500 hr.	0.00058	0.52	0.00039	0.32	0.00017	0.21	0.00012	0.175
1 000 hr.	0.00054	0.80[a]	0.000335	0.50	0.00015	0.28	0.00012	0.24
1 400 hr.	....	....	0.00026	0.60[a]	0.00013	0.34	0.00010	0.28
2 000 hr.	....	....	....	....	0.00011	0.40	0.00009	0.34
3 000 hr.	....	....	....	....	0.00010	0.51	0.00009	0.425
4 000 hr.	....	....	....	....	0.00009	0.605	0.000075	0.50
5 000 hr.	....	....	....	....	0.000075	0.688	0.000025	0.56
6 000 hr.	....	....	....	....	0.000075	0.763	0.00007	0.60
7 000 hr.	....	....	....	....	0.000075	0.844	0.00006	0.712
8 000 hr.	....	....	....	....	0.000085	0.919	0.00006	0.773[c]
9 000 hr.	....	....	....	....	0.000095	1.015[b]	....	.....
10 000 hr.	....	....	....	....	....	......	....	.....

[a] Test discontinued.

[b] Test discontinued, rate of deformation 0.000095 per cent per hr. and total deformation 1.07 per cent at 9617 hr.

NOTE.—The values for total deformation of specimen No. 10A-4 subsequent to 7125 hr. are corrected to take into account deformation resulting from the controller failure.

[c] Test continuing, rate of deformation 0.00006 per cent per hr. and total deformation 0.819 per cent at 8700 hr.

CONCLUSION

The long-time creep test data herein reported emphasize the fact that extrapolations based on the assumption that the rate of creep determined at the end of a thousand hours or so will continue at that rate, may be misleading. The data make evident the fact that a thorough-going knowledge of the extent of the strain-hardening temperature range of a material must be added to the usual creep data, determined in or near that range, before sound design figures can be set.

Respectfully submitted on behalf of the committee,

H. C. CROSS,
F. B. DAHLE.

REPORT OF COMMITTEE B-1

ON

COPPER AND COPPER ALLOY WIRES FOR ELECTRICAL CONDUCTORS

Committee B-1 on Copper and Copper Alloy Wires for Electrical Conductors held two meetings during the year; in Pittsburgh, Pa., on March 3, 1936, and in New York, N. Y., on May 14, 1936.

The committee has adopted the title given above as more adequately designating the scope of its work than the former title: namely, Committee B-1 on Copper Wire.

The election of officers resulted in the reelection of the present incumbents for the ensuing term of two years.

Several changes in personnel of the committee have taken place during the year. Mr. J. Franklin Meyer has replaced Mr. Frank Wenner as the representative of the National Bureau of Standards. Mr. Albert M. Hagen of the General Cable Corp. has replaced Mr. G. L. Hawley, and Mr. G. L. Hadden of Henry L. Doherty and Co. has resigned. Committee B-1 now has 26 members of whom 12 are classified as consumers, 12 as producers, and 2 as general interests members.

The Subcommittee on Electric Transmission Wire and Cable Specifications (G. E. Dean, chairman) has made progress rather slowly, due largely to the serious illness of its chairman. It is expected that substantial progress will be possible during the ensuing year in connection with the Tentative Specifications for Hard-Drawn Copper Transmission Cable (B 87 – 32 T) for which this subcommittee is responsible.

RECOMMENDATIONS AFFECTING STANDARDS

I. *Proposed Tentative Standard:*

Proposed Tentative Specifications for Hard-Drawn Copper Alloy Wires for Electrical Conductors.—It has become evident that there is a need for specifications covering a variety of copper alloy wires for electrical conductors. Such specifications are necessary so that producers and consumers may both be in position properly to coordinate various proposals and to make readily available equivalent high-strength conductors. To facilitate these matters, a working standard has for some time been in existence and has been used by various producers even though this working standard had no official sponsorship. Later, A.S.T.M. Committee B-5 on Copper and Copper Alloys, Cast and Wrought was asked to consider the matter and appointed a subcommittee to draft a proper standard for this material. Still later, the sponsorship of this work was delegated to Committee B-1. This committee has correlated the various suggestions and has prepared the proposed specifications for this material appended hereto which are recommended for publication as tentative.

II. Adoption of Tentative Standards as Standard:

Tentative Specifications for Bare Stranded Copper Cable: Hard, Medium-Hard or Soft (B 8 – 35 T).[2]—The committee has prepared certain revisions in these specifications as detailed below and recommends that as thus revised they be approved for reference to letter ballot of the Society for adoption as standard. These specifications supersede the present Standard Specifications for Bare Concentric-Lay Copper Cable: Hard, Medium-Hard or Soft (B 8 – 27) which are to be discontinued. The revisions are as follows:

Section 2.—Change Paragraph (*b*) to read as follows by the addition of the italicized words and the omission of those in brackets:

> (*b*) In concentric-lay cables, the central core shall be made of wire [having the same quality] *of the same type* and temper as the concentric layers unless otherwise specified.

Section 3.—Change from its present form: namely,

> 3. Brazes shall not be permitted in hard-drawn or medium hard-drawn Class AA cables of seven wires or less. In other cables, brazes may be made in the wire when finished and ready for cabling. Such brazes shall be made in accordance with the best commercial practice. Brazes shall not be closer together than as shown in the following table:

NUMBER OF WIRES IN CABLE	HARD OR MEDIUM-HARD	SOFT
3	no brazes permitted	[a]
7 to 36, incl	50 ft.	[a]
37 to 60, incl	25 ft.	[a]
61 and over	5 ft.	[a]

[a] Cable may not be brazed as a unit.

to read as follows:

> 3. Joints may not be made in the finished wires composing hard-drawn or medium hard-drawn Class *AA* cables of seven wires or less. Welds and brazes may be made in rods or in wires prior to final drawing. In other cables, welds and brazes may also be made in the finished individual wires composing the cable, but shall not be closer together than as shown in the following table:

---

[1] See p. 760.

[2] *Proceedings,* Am. Soc. Testing Mats., Vol. 35, Part I, p. 736 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 330.

NUMBER OF WIRES IN CABLE	HARD OR MEDIUM-HARD	SOFT
3	no joints permitted	[a]
7 to 36, incl	50 ft.	[a]
37 to 60, incl	25 ft.	[a]
61 and over	5 ft.	[a]

[a] Cable may not be jointed as a unit.

Section 6.—Insert a new Paragraph (*b*) reading as follows, relettering the present Paragraphs (*b*) and (*c*) as (*c*) and (*d*):

> (*b*) If a tinning test is required, it shall be made on the wires prior to stranding.

Section 7.—Change Paragraph (*b*) to read as follows by the addition of the italicized words and the omission of those in brackets:

> (*b*) The electrical resistance and [mass] *weight* of a stranded conductor are greater than the total of these characteristics of the wires composing the cable, depending upon the lay or pitch. Two per cent shall be taken as the standard increment *of increase* of resistance and [mass] *weight* of concentric-lay cable. In cases where the lay is definitely known, the increment shall be calculated and not assumed.

Section 8.—Change to read as follows by the addition of the italicized words:

> 8. The area of cross-section of the completed cable shall be not less than 98 per cent of the area specified. The area of cross-section shall be considered to be the sum of the cross-sectional areas of its component wires *at any point* when measured perpendicularly to their axes.

Tentative Specifications for Bronze Trolley Wire (B 9 – 35 T).[1]—These specifications have been reviewed by the committee with the result that it recommends that these tentative specifications be approved for reference to letter ballot of the Society for adoption as standard, without revision. These specifications supersede the present Standard Specifications for Bronze Trolley Wire (B 9 – 32) which are to be discontinued.

III. *Adoption of Tentative Revision of Standard as Standard:*

Standard Specifications for Copper Trolley Wire (B 47 – 32).[2]—The committee recommends the adoption as standard of the revisions in the dimensional tolerances of these specifications published as tentative[3] in 1935, the revised Fig. 1 replacing the present figure in the specifications. It is accordingly recommended that this revision be approved for reference to letter ballot of the Society for adoption.

IV. *Withdrawal of Standards:*

The committee recommends the withdrawal of the following two standards which are being replaced by completely revised specifications as mentioned earlier in this report:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 740 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 338.

[2] 1933 Book of A.S.T.M. Standards, Part I, p. 752.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1391 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 1517.

Standard Specifications for Bare Concentric-Lay Copper Cable: Hard, Medium-Hard or Soft (B 8 – 27),[1] and
Standard Specifications for Bronze Trolley Wire (B 9 – 32)[2]

The recommendations appearing in this report have been submitted to letter ballot of the committee, which consists of 26 members, the results being as follows:

Items	Affirmative	Negative	Ballots Marked "Not Voting"
I. PROPOSED TENTATIVE STANDARD			
Tentative Specifications for Hard-Drawn Copper Alloy Wires for Electrical Conductors	22	0	3
II. ADOPTION OF TENTATIVE STANDARDS AS STANDARD			
Specifications for Bare Stranded Copper Cable: Hard, Medium-Hard or Soft (B 8 – 35 T), as revised	21	1	3
Specifications for Bronze Trolley Wire (B 9 – 35 T)	15	1	10
III. ADOPTION OF TENTATIVE REVISION OF STANDARD AS STANDARD			
Specifications for Copper Trolley Wire (B 47 – 32)	18	1	7
IV. WITHDRAWAL OF STANDARDS			
Specifications for Bare Concentric-Lay Copper Cable: Hard, Medium-Hard or Soft (B 8 – 27)	20	0	6
Specifications for Bronze Trolley Wire (B 9 – 32)	15	1	10

This report has been submitted to letter ballot of the committee which consists of 26 members; 25 members returned their ballots, of whom 24 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

J. A. CAPP,
Chairman.

J. H. FOOTE,
Secretary.

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[1] 1933 Book of A.S.T.M. Standards, Part I, p. 746.
[2] *Ibid.*, p. 757.

REPORT OF COMMITTEE B-2
ON
NON-FERROUS METALS AND ALLOYS

Committee B-2 on Non-Ferrous Metals and Alloys since the presentation to the Society of its report in 1935 has held one meeting in Detroit, Mich., on June 27, 1935. This meeting was in effect an open meeting of the Advisory Committee wherein the general reorganization of Committee B-2 was discussed. This matter had been under consideration for over a year.

Mr. H. V. Churchill, chairman of Subcommittee VII on Methods of Sampling and Chemical Analysis, reported that the Society after consultation with the various standing committees on ferrous and non-ferrous metals, had decided to organize a new Committee E-3 on Chemical Analysis of Metals. Since this new committee would be responsible for the preparation of standard methods of chemical analysis of metals, including methods of sampling and tolerance values obtained in chemical analysis of metals, Committee B-2 decided to discontinue its Subcommittee VII with an expression of appreciation to the chairman and members of the subcommittee for their many services to the committee.

A general plan of reorganization of the committee has been adopted which involves the abandonment of all former subcommittees and the reconstitution of other groups with specific assignments, as follows:

- Subcommittee I on Refined Copper (H. C. Jennison, chairman),
- Subcommittee II on Refined Lead, Tin, Antimony and Bismuth (T. A. Wright, chairman),
- Subcommittee III on White Metal Alloys (G. H. Clamer, chairman),
- Subcommittee IV on Refined Zinc and Wrought Zinc (E. H. Bunce, chairman),
- Subcommittee V on Precious Metals and Alloys (R. H. Leach, chairman),
- Subcommittee VI on Coated Metals (W. G. Schneider, chairman),
- Subcommittee VII on Refined Nickel and High Nickel Alloys, Cast and Wrought (C. E. Margerum, chairman), and
- Subcommittee VIII on Miscellaneous Refined Metals and Alloys (E. E. Schumacher, chairman).

All members of Committee B-2 are being invited to enroll on those subcommittees in whose work they are interested.

There are no revisions in the standards and tentative standards under the jurisdiction of this committee to be presented to the Society at this time and it is accordingly recommended that they be continued in their present status.

The officers of the committee and of the various subcommittees have been continued for the ensuing term of two years.

This report has been submitted to letter ballot of the committee which consists of 96 members; 54 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee.

R. F. MEHL,
Chairman.

E. E. THUM,
Secretary.

REPORT OF COMMITTEE B-4
ON
ELECTRICAL-HEATING, ELECTRICAL-RESISTANCE AND ELECTRIC-FURNACE ALLOYS

Committee B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys held two meetings during the year, in New York City on November 11 and 12, 1935, and in Washington, D. C., on February 20 and 21, 1936, respectively, in addition to the meeting held during the annual meeting of the Society.

The committee consists of 31 members, of whom 15 are classified as producers, 12 as consumers and 4 as general interests.

RECOMMENDATIONS AFFECTING STANDARDS

I. Proposed Tentative Standard.—The committee recommends that the proposed Tentative Method of Test for Flexivity of Thermoflex (Thermostatic Metals), as appended hereto,[1] be accepted for publication as tentative.

II. Proposed Revision of Standards.—The committee proposes for immediate adoption revisions of the following three standard methods. It accordingly asks for the necessary nine-tenths vote at the annual meeting in order that these revised standards may be referred to letter ballot vote of the Society for immediate adoption:

Standard Method of Test for Resistivity of Metallic Materials for Resistors (B 63 – 29),[2] revised as appended hereto;[3]

Standard Method of Test for Determining the Temperature-Resistance Constants of Resistance Alloys (B 84 – 34),[4] revised as appended hereto;[3]

Standard Accelerated Life Test for Metallic Materials for Electrical Heating (B 76 – 33),[5] revised as indicated below:

Section 3.—In Paragraph (*e*) change the last sentence from its present form: namely,

> The ammeter has appreciable resistance; therefore, after it has been cut out of circuit, a slight readjustment of current with the slider will be necessary to bring the voltmeter back to the value corresponding to standard test temperature.

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[1] See p. 765.
[2] 1933 Book of A.S.T.M. Standards, Part I, p. 892.
[3] See 1936 Book of A.S.T.M. Standards, Part I, pp. 749, 752.
[4] 1934 Supplement to Book of A.S.T.M. Standards, p. 83.
[5] 1933 Book of A.S.T.M. Standards, Part I, p. 877.

to read as follows:

> The ammeter has appreciable resistance. A compensating resistance shall be cut into the circuit to replace the resistance of the ammeter so that the over-all resistance of the circuit is not changed. This resistance shall be inserted in series with the blade of the upper switch shown in Fig. 2.

Section 7.—Change to read as follows by the addition of the italicized figures and the omission of the figures in brackets:

> 7. Alloys of class A shall be tested at a temperature of [1066 C. (1950 F.)] *2050 F. (1120 C.)* and alloys of class B at a temperature of [1010 C. (1850 F.)] *1950 F. (1065 C.)*

Section 8.—In Paragraph (*a*) add the following sentence between the present first and second sentences:

> Adjust the switches so that the voltmeter and ammeter are in circuit while the temperature is being adjusted.

In Paragraph (*h*) change the first sentence to read as follows by the addition of the italicized figure and the omission of the figure in brackets:

> (*h*) Allow the test to continue until [9] *14* minutes have elapsed from the time of starting the test.

Appendix.—In the Appendix add to the section on Temperature preceding the present paragraphs, three new paragraphs to read as follows:

> *Temperature.*—In general, it has been found desirable to use a temperature for any particular alloy which will result in a total life of approximately 100 hr.
>
> Experience has indicated that this is a sufficient length of life to give a fair index of the quality of the material. A measure of the necessary length of time to get a good life test is shown by the consistency of the results; for example, if the test temperature is too high, the results are likely to be inconsistent since the excessive temperature causes aggravated hot spot conditions.
>
> In addition to the temperature, care must be used in general applications of the test method to various types of alloys, particularly those of low creep strength. It will be noted in the test method that a weight is placed on the specimen in order to keep it straight and this weight has been calculated within the creep strength for the nickel-chromium alloy type material. For other types of material, with very low creep strengths, the test must be modified to eliminate any loading which would approach the creep value of the material at the temperature of test.

Following the section on temperature add to the Appendix a section on Specimen Enclosure to read as follows:

> *Specimen Enclosure.*—To allow observation of specimen, a number of laboratories have found it desirable to use a glass slide in the front of the enclosure in preference to the metal slide. This permits reading the temperature without removing the slide or without inserting the pyrometer into the tube as shown in the drawing.
>
> If glass is used, the pyrometer observation shall be corrected to compensate for the absorption of the glass slide. The glass shall be kept clean to avoid increase in the absorption.

The committee also recommends that the following editorial changes be made immediately in the Standard Method of Test for Thermoelectric Power of Electrical-Resistance Alloys (B 77 – 33):[1]

Section 1.—Change to read as follows by the addition of the italicized words:

1. This method is intended for testing the thermoelectric power of a metal *or alloy* with respect to copper when the temperatures of the junctions lie between 0 and 100 C.

Section 4.—Change the note to this section to read as follows by the addition of the italicized word and the omission of the word in brackets:

NOTE.—When necessary to specify the quality of the copper [contacts] *leads* reference should be made to the Standard Specifications for Soft or Annealed Copper Wire (A.S.T.M. Designation: B 3) of the American Society for Testing Materials.

Section 5.—Change the sixth sentence to read as follows by the omission of the words in brackets:

The temperature of the oil in each bath may be determined either by a calibrated mercury thermometer [graduated in Centigrade degrees] or by a calibrated thermocouple.

Section 7.—Change to read as follows by the addition of the italicized words and the omission of the word in brackets:

7. The metal or alloy tested shall be considered to have positive polarity when, in a circuit consisting of copper and the metal or alloy, the direction of current flow in the metal or alloy is from the *junction having the* higher *temperature* to the *one having the* lower temperature [junction.]

Section 8.—Change Paragraph (*a*) to read as follows by the addition of the italicized words:

(*a*) The character of the metal tested *and identification of specimen;*

The recommendations appearing in this report have been submitted to letter ballot of the committee, which consists of 31 members; 25 members returned their ballots, the results being as follows:

Items	Affirmative	Negative	Ballots Marked "Not Voting"
I. PROPOSED TENTATIVE STANDARD			
Method of Test for Deflectivity of Thermoflex (Thermostatic Metals)	22	0	3
II. PROPOSED REVISIONS OF EXISTING STANDARDS			
Method of Test for Resistivity of Metallic Materials for Resistors (B 63 – 29), immediate adoption	24	0	1
Method of Test for Determining the Temperature-Resistance Constants of Resistance Alloys (B 84 – 34), immediate adoption	24	0	1
Accelerated Life Test for Metallic Materials for Electrical Heating (B 76 – 33), immediate adoption	21	0	4
Method of Test for Thermoelectric Power of Electrical-Resistance Alloys (B 77 – 33), editorial revision	24	0	1

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[1] 1933 Book of A.S.T.M. Standards, Part I, p. 895.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Life Tests (J. W. Harsch, chairman).—Recommendations have been submitted to increase the test temperature in the Standard Accelerated Life Test for Metallic Materials for Electrical Heating (B 76 – 33) for class A heater wires from 1950 F. (1065 C.) to 2050 F. (1120 C.) and for class B wires from 1850 F. (1010 C.) to 1950 F. (1065 C.). This is considered necessary to expedite the test as commercial grades of heater wires have been so much improved in quality since the test was developed by the committee that they require an excessive length of time. Tests have shown that the increase in temperature of 100 F. considerably shortens the time, but that the same relative values for life of the test specimens are obtained as with the present test. A glass slide is under consideration to be used in the testing equipment for protection against temperature variations, with compensation for absorption of the glass in temperature measurement.

A new section under the chairmanship of Mr. W. A. Gatward has been organized to develop a standard life test method for heater elements for operation in electric furnaces. This application requires a different test and higher temperatures than the present accelerated life test which was developed for electrical heating appliances.

Subcommittee II on Electrical Tests (H. L. Curtis, chairman).—The Standard Methods of Test for Resistivity of Metallic Materials (B 63 – 29), for Temperature-Resistance Constants (B 84 – 34), and for Thermoelectric Power of Electrical-Resistance Alloys (B 77 – 33) have been revised, as mentioned earlier in this report, the changes being mainly editorial.

In the development of a standard method of test for temperature coefficient of manganin, a study is being made of the method of annealing the specimen.

Subcommittee IV on Mechanical Tests (P. H. Brace, chairman).—A number of bend testing machines for determining the stiffness of electrical resistance wires have been investigated. They are of three types in which the bending force is produced by:

A. The impact of a freely falling pendulum.
B. A bending moment applied by means of an unbalanced lever which maintains contact with the specimen during the bending operation.
C. An accurately predetermined bending moment obtained by a manually operated mechanism.

In each case the stiffness is measured by the angle of permanent bend of the specimen.

A Proposed Method for the Bend Testing of Wire has been prepared including the three types of machines, and is being recommended for publication as information and appears in the Appendix to this report.

Subcommittee V on Wrought and Cast Alloys for High-Temperature Use (C. L. Clark, chairman).—The proposed casting technique for producing the long tension test specimens for high-temperature tests has been found satisfactory. The X-ray analysis of castings from three foundries has shown them to be sound. The specimens have been made of sufficient length so that the ends to be gripped in the testing machine are outside of the electric heater on the specimen, to avoid making connections in the heated zone. Tests are now being made at 1600 F. in accordance with the Tentative Method of Test for Short-Time High-Temperature Tension Tests of Metallic Materials (E 21 – 34 T).

A warpage test specimen in the form of an eccentric tube, being studied in connection with a method to determine the relative tendency of alloys to warp at elevated temperatures, is under consideration. To expedite the action, specimens of several alloys were heated, then quenched in water. Further tests are being made with oil as the coolant.

The high-temperature bend test has been outlined, using a rectangular beam loaded at the center, and preliminary tests are being made on a 20 per cent chromium, 32 per cent nickel alloy.

High-temperature oxidation and corrosion tests are under consideration, also a high-temperature compression test.

Subcommittee VII on Thermostatic Metals (P. H. Brace, chairman).—The program of tests carried on in several laboratories to determine the flexivity, deflection stiffness and hardness of thermoflex (thermostatic metals) has given favorable results. A Method of Test for Flexivity of Thermoflex (Thermostatic Metals), appended hereto,[1] has been prepared and is being submitted for publication as tentative. This method describes the essential requirements of the apparatus and test procedure, giving latitude for the use of different testing equipment but insuring comparable results. Methods of test for other properties of thermoflex are under consideration.

The election of officers for the ensuing term of two years resulted in the re-election of the present incumbents.

This report has been submitted to letter ballot of the committee which consists of 31 members; 25 members returned their ballots, of whom 24 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

DEAN HARVEY,
Chairman.

F. E. BASH,
Secretary.

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[1] See p. 765.

APPENDIX

PROPOSED METHOD FOR THE BEND TESTING OF WIRE[1]

This is a **proposed draft** and is published as information only. Comments are solicited and should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

1. *Scope.*—This method is intended to evaluate the resistance to bending of wire from about 0.010 to 0.117 in. (0.25 to 3.0 mm.) in diameter.

2. *Nature of Bend Test.*—The test consists in clamping the specimen rigidly at one end, subjecting the wire to a bending force and measuring the resulting permanent angular deflection. The bending force may be produced by the following:

A. The impact of a freely falling pendulum,
B. A bending moment applied by means of a weighted arm which maintains contact with the specimen during the bending operation, and
C. An accurately predetermined bending moment applied by a manually operated mechanism.

In each case the stiffness is regarded as being inversely proportional to the angle of permanent bend of the specimen.

3. *Apparatus.*—The apparatus shall include the following elements:

(*a*) A frame having sufficient weight and rigidity to prevent appreciable vibration,
(*b*) A specimen clamp to hold the specimen in position for test,
(*c*) A bending die for applying the test load,
(*d*) Means for adjusting and indicating the test load,
(*e*) Means for measuring angular positions and ranges of motion of the loading system,
(*f*) Means for accurately determining the free positions of the specimen before and after bending, and
(*g*) Means for leveling the apparatus to within 0.25 deg. if gravity is used for actuating the loading mechanism.

The specimen clamp and the bending die shall conform to the arrangement and dimensions shown in Fig. 1.

4. *Test Specimen.*—(*a*) The test specimen shall be long enough to permit it to be securely held in the specimen clamp. In general, the clamped portion shall be not less than $\frac{3}{8}$ in. in length. The test specimen shall be of sufficient length so that it will always extend beyond the edge of the bending die.

(*b*) The specimen shall not be straightened prior to test. In order to secure samples representative of the original material, great care shall be taken to avoid any plastic deformation of the wire in removing it from the spool or coil, and in subsequent handling. Even slight bending may markedly alter the stiffness of the wire.

(*c*) Any lubricant or other coating which would prevent electrical contact of the wire with the clamp and bending die shall be removed in such a manner as not to affect the stiffness of the wire.

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[1] Under the standardization procedure of the Society, this proposed method is under the jurisdiction of the A.S.T.M. Committee B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys.

5. *Measurement of Specimen Diameter.*—Specimens of clean wire shall be carefully straightened by rolling lightly between plane surfaces or by other means which do not change the diameter. The diameter shall then be measured with a 1-in. machinist's micrometer having anvil and spindle surfaces 0.250 in. in diameter, and equipped with vernier and ratchet, or by other method as agreed upon. The average of the three measurements at intervals of approximately 60 deg. around the wire shall be taken as the diameter of the specimen.

METHOD A

6. *Construction of Testing Machine.*—A light pendulum rotates about a horizontal axis. The pendulum carries a bending die and a weight which may be placed in different positions on the pendulum arm. One end of the specimen is held in the clamp and the other end is free. When the pendulum falls the bending die strikes the specimen near the free end, causing a permanent bend. The pendulum arm carries a pointer which moves along an index scale, thus allowing the measurement of the angle through which the specimen has been bent. (See Fig. 2 (*a*) and (*b*).)

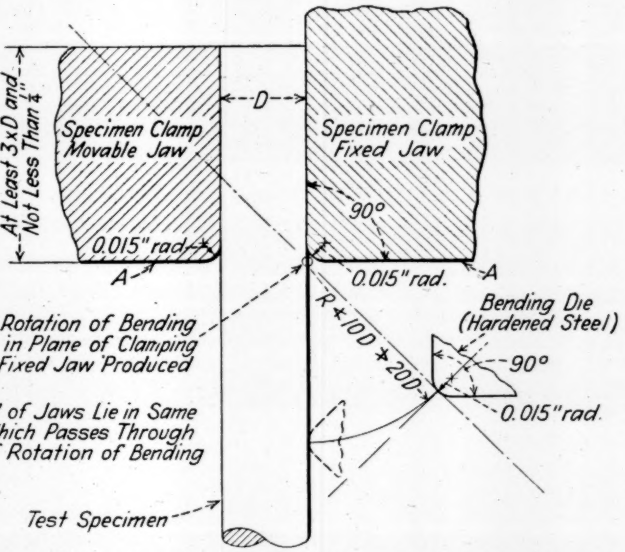

At Least 3×D and Not Less Than 1/4"
D
Specimen Clamp Movable Jaw
Specimen Clamp Fixed Jaw
90°
0.015" rad.
A
0.015" rad.
A
R ± 10D ± 20D
Bending Die (Hardened Steel)
90°
0.015" rad.
Axis of Rotation of Bending Die Lies in Plane of Clamping Face of Fixed Jaw Produced
Faces "A" of Jaws Lie in Same Plane Which Passes Through Axis of Rotation of Bending Die
Test Specimen

FIG. 1.—Arrangement and Details of Specimen Clamp and Bending Die.

7. *Leveling of Machine.*—The machine shall be so leveled that the axis of rotation is horizontal within 1 deg. and so that the pendulum arm will hang freely within 0.5 deg. of the zero mark.

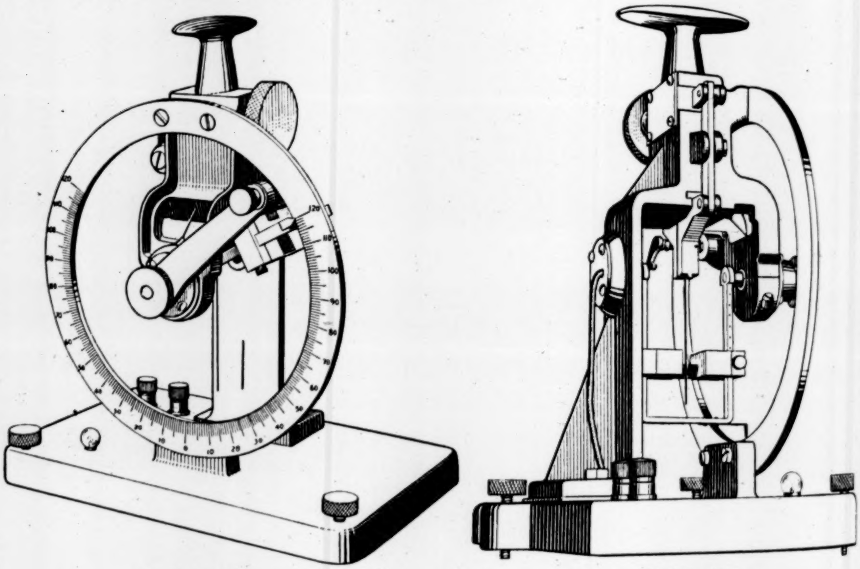
8. *Pendulum Friction.*—The pendulum hammer, when dropped freely from the 90-deg. position on three successive trials, shall rise to the same position within 1.5 deg. and this position shall be above the 87-deg. position on the opposite side.

NOTE.—The following procedure has been found to be satisfactory as a check: The machine having been leveled, the arm carrying the bending die is latched up to a given angle on the right side of the dial. The latch is then released and the height of the swing on the left side of the dial noted. A metal straightedge is lightly attached to the dial so that the pointer of the arm touches the straightedge when the arm is at the apex of its initial swing. The point at which the up swinging arm just touches the straightedge can be found by a few trial swings. Moving the straightedge 0.25 deg. upward then should put it beyond the reach of the swinging arm, while the arm should visibly push the straightedge up when the straightedge is depressed 0.25 deg. from the "just-touch" position.

9. *Specimen Clamp.*—The specimen clamp shall conform to the requirements given in Fig. 1.

10. *Procedure: (a) Mounting of Specimen.*—The specimen shall be fastened in the specimen clamp in such a manner that the bending die will just touch the specimen when the pendulum is hanging freely in its zero position.

(*b*) *Test Routine.*—With the specimen clamped in position the pendulum shall be raised to the predetermined initial position and allowed to fall freely to strike the specimen. The bending die shall be allowed to swing against the specimen but once, and it shall be caught on the rebound. The angle through which the pendulum index must be moved from its zero position when hanging freely to cause the bending die to just make contact with the bent specimen shall then be observed and recorded. This angle shall be taken as the angle of bend.



(*a*) Front View. (*b*) Side View.

FIG. 2.—Method A, Bend Test Machine.

NOTE.—Contact of the bending die with the specimen must be definitely indicated by some means which will not involve measurable deflection of the wire. Electrical means of indicating contact (battery and lamp) have been found convenient.

For very small wires, such as 0.010 to 0.020 in. (0.25 to 0.50 mm.) in diameter of nickel wire, and for slightly dirty or oxidized specimens, it has been found convenient to use a telephone head set and battery connected to the clamp and frame of the machine. A vacuum tube relay circuit also has been used successfully.

11. *Bend Limit.*—Since the most accurate indication of the quality of the wire is obtained if the test bend falls between 30 and 70 deg., the bend shall be kept within these limits. This may be done by making a few trials, and adjusting the weight of pendulum, radius of swing or height of fall.

12. *Report.*—The report shall include the following:

(*a*) Identification of specimen,

(*b*) Diameter of specimen,

(*c*) Relation of the plane of curvature of the specimen with reference to the plane of the face of the specimen clamp,

(*d*) Machine adjustment:
  (*1*) Pendulum weight,
  (*2*) Radius of swing of center of gravity of pendulum weight, and
  (*3*) Angle of fall.
(*e*) Angle of bend, and
(*f*) Gage length.

METHOD B

13. *Construction of Testing Machine.*—(*a*) A pivoted arm, in static equilibrium in both vertical and horizontal planes, carries a bending die having its working edge parallel to the axis of rotation of the arm. The specimen is held in the specimen clamp in such a position that contact with the bending die is just made when the arm is in the horizontal position. When the weighted arm is released from its horizontal position, gravity causes it to move downward, causing the specimen to bend. (See Fig. 3.)

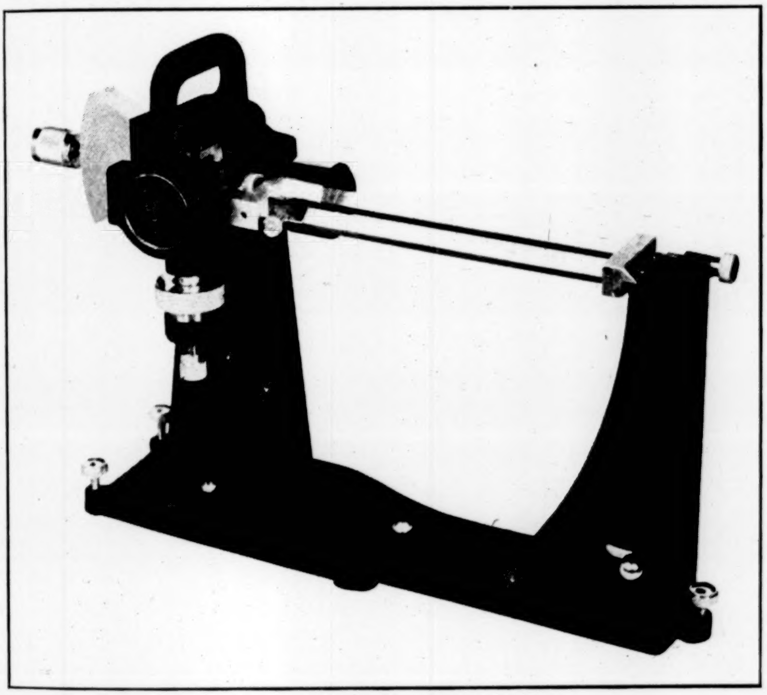


FIG. 3.—Method B, Bend Test Machine.

(*b*) The weight on the arm is adjusted by trial so as to cause the specimen to bend through an angle of approximately 30 deg. The resistance to bending is indicated by the energy expended in bending the specimen. The energy is determined from the magnitude and the location of the weight on the lever arm and the angle at which the arm comes to rest.

14. *Leveling of Machine.*—The machine shall be leveled by means of a spirit level or equivalent method.

15. *Specimen Clamp.*—The clamp shall conform to the requirements shown in Fig. 1.

16. *Sensitivity of Arm.*—The arm shall be mounted in bearings which will permit it to descend steadily when weighted to provide a turning moment of 5 g–cm.

17. *Balancing the Arm.*—The bending die shall be set at the required position. Horizontal balance shall be obtained by adjustment of the counter weight, tapping the instrument lightly to increase the sensitivity. Then, with the arm at about 35 deg. below the horizontal, repeat the tapping and adjust the vertical poise until vertical balance is obtained.

18. *Procedure:* (*a*) *Mounting of Specimen.*—The specimen shall be fastened in the clamp in such a position that contact with the bending die is just made when the arm is held in the horizontal position. Electrical means such as a miniature lamp bulb and battery shall be provided to indicate contact between the specimen and the bending die.

(*b*) *Adjustment of Load.*—Under the influence of a weight applied to the free end of the arm, the latter moves downward due to gravity, causing the specimen to bend when the beam is released. The weighting of the arm shall be adjusted by trial so as to cause the specimen to bend through an angle of approximately 30 deg. The bend arm shall then be lifted sufficiently to break contact between the bending die and the specimen and finally return until contact is just made. The angle of permanent bend shall be taken as that indicated by the pointer in the last mentioned position.

(*c*) *Test Routine.*—With the specimen in place, the weighted arm shall be allowed to fall. The angle between the initial and final positions of the arm shall be recorded.

19. *Report.*—The report shall include the following:

(*a*) Identification of specimen,
(*b*) Diameter of specimen,
(*c*) Relation of the plane of curvature of the specimen with reference to the plane of the face of the specimen clamp,
(*d*) Machine adjustment:
  (*1*) Weight on lever arm.
  (*2*) Distance of center of gravity of weight to its axis of rotation, and
  (*3*) Angular movement of arm.
(*e*) Angle of permanent bend, and
(*f*) Gage length.

METHOD C

20. *Construction of Testing Machine.*—The machine includes a shaft rotating about a horizontal axis, to which is attached the specimen clamp. A pendulum rotating about the same axis as the shaft is provided with adjustable weights and carries the bending die. One end of the specimen is held in the specimen clamp and the latter is rotated so as to bring the specimen in contact with the bending die and deflect the pendulum against gravity, through the desired angle measured by a scale attached to the pendulum and a pointer on the base of the machine. The clamp is then rotated in the reverse direction until the pendulum hangs freely with the specimen just making contact with the bending die. The angle through which the specimen has been permanently bent is indicated by the angular difference between the initial and final positions of the rotating clamp. (See Fig. 4.)

21. *Accuracy.*—The machine shall be accurate within 1 per cent of its capacity. When the pendulum is allowed to come to rest it shall assume the same position within 1.0 deg.

22. *Leveling of Machine.*—The machine shall be leveled by means of a spirit level or equivalent method.

23. *Specimen Clamp.*—The specimen clamp shall conform to the requirements given in Fig. 1.

24. *Procedure:* (*a*) *Mounting of Specimen.*—The specimen shall be fastened in the specimen clamp, and the clamp and specimen shall be rotated until the specimen just makes contact with the bending die on the pendulum. The pointer attached to the specimen clamp shall then be set at the zero position of the scale.

(*b*) *Test Routine.*—Rotation of the clamp and specimen shall then be continued, causing the pendulum to be deflected through the desired angle. The direction of rotation shall then be reversed until contact between pendulum and specimen is broken and the pendulum then advanced until contact is just made.

The position of the pointer attached to the clamp shall then be recorded as a measure of the angle through which the specimen has been bent.

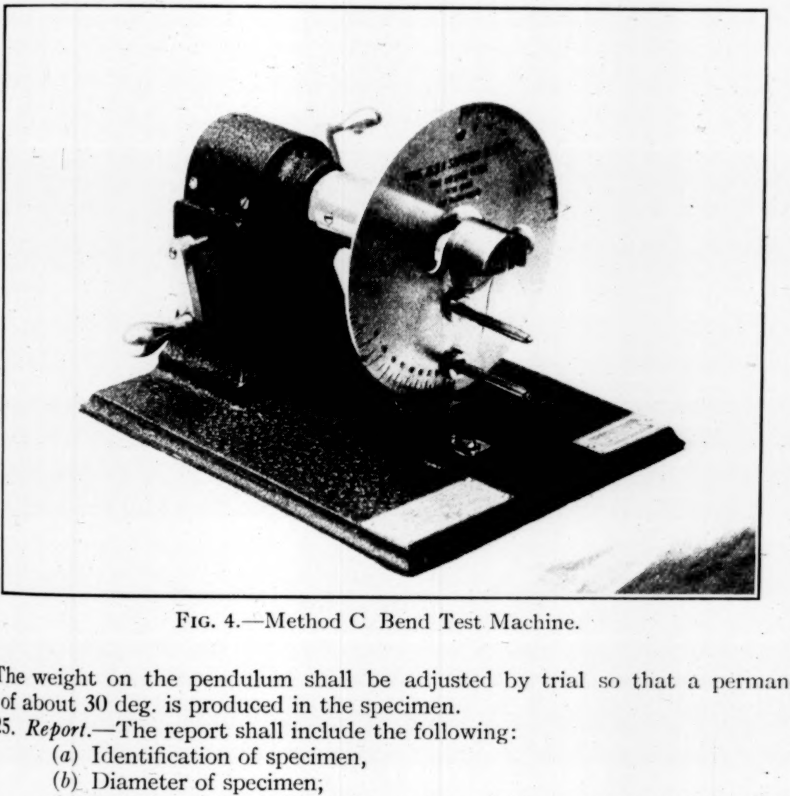


FIG. 4.—Method C Bend Test Machine.

The weight on the pendulum shall be adjusted by trial so that a permanent bend of about 30 deg. is produced in the specimen.

25. *Report.*—The report shall include the following:

- (*a*) Identification of specimen,
- (*b*) Diameter of specimen,
- (*c*) Relation of the plane of curvature of the specimen with reference to the plane of the face of the specimen clamp,
- (*d*) Machine adjustment:
  - (*1*) Pendulum weight,
  - (*2*) Radius of swing, and
  - (*3*) Angle of deflection of pendulum.
- (*e*) Angle of permanent bend, and
- (*f*) Gage length.

REPORT OF COMMITTEE B-5

ON

COPPER AND COPPER ALLOYS, CAST AND WROUGHT

Committee B-5 on Copper and Copper Alloys, Cast and Wrought, held two meetings during the year, at Detroit, Mich., on June 26, 1935, and at Pittsburgh, Pa., on March 4, 1936.

Subsequent to its meeting last June, Committee B-5 presented to the Society, through Committee E-10 on Standards, Tentative Specifications for Hard Drawn Copper Alloy Wires and a revision of the table of physical properties in the Tentative Specifications for Copper-Silicon Alloy Wire for General Purposes (B 99 – 35 T). Action of Committee E-10 on the first of these recommendations was withheld pending their review by the Society's Committee B-1 on Copper Wire inasmuch as these specifications covered conductor wire and the principal representation of the consumer interest in this field is found in Committee B-1. Subsequently, the matter of jurisdiction over these specifications was referred to the Coordinating Committee on Non-Ferrous Metals and Alloys, which recommended that these specifications be assigned to Committee B-1 with the understanding that this committee will hereafter be known as Committee B-1 on Copper and Copper Alloy Wires for Electrical Conductors. It is expected that these specifications will receive further consideration in Committee B-1 looking towards their submission to the Society at the annual meeting in June for publication as tentative.[1] The revision of the Tentative Specifications for Copper-Silicon Alloy Wire for General Purposes was accepted by Committee E-10 at a meeting held on August 22, 1935.[2] The specifications in their revised form appear in the 1935 *Proceedings*,[3] and 1935 Book of A.S.T.M. Tentative Standards.[3]

RECOMMENDATIONS AFFECTING STANDARDS

I. Proposed Tentative Standards.—The committee recommends for publication as tentative the following five specifications, of which two relate to materials not previously covered by A.S.T.M. standards and three represent revisions of existing standards:

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[1] See Report of Committee B-1 on Copper and Copper Alloy Wires for Electrical Conductors, see p. 151.

[2] In submitting the revision of these tentative specifications to Committee E-10 on Standards, Committee B-5 reported results of the letter ballot vote as follows: Of a total membership of 60, 44 members returned their ballots, of whom 30 voted affirmatively, none negatively, and 14 members marked their ballots "not voting."

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 750 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 359.

Tentative Specifications for Seamless Copper-Nickel Alloy Condenser Tubes and Ferrule Stock.—These specifications, which are recommended for publication as tentative as appended hereto,[1] were prepared by Subcommittee I on Wrought Metals and Alloys (D. K. Crampton, chairman) to satisfy standardization requirements affecting a type of commercial material of growing importance.

Tentative Specifications for Sheet and Strip Phosphor Bronze.—These specifications which are recommended for publication as tentative, as appended hereto,[2] were also undertaken by Subcommittee I in response to requests to prepare such purchase requirements to meet the needs of producing interests and consumers in standardizing this type of material which is now in common use.

Tentative Specifications for Bronze Castings for Turntables and Movable Bridges.—These specifications, which are appended hereto,[3] were prepared by Subcommittee II on Cast Metals and Alloys (G. H. Clamer, acting chairman) as a revision of the present Standard Specifications for Bronze Bearing Metal for Turntables and Movable Railroad Bridges (B 22 – 21).[4] Besides the change in title, the section on scope has been changed to define more properly the application of the four classes of bronze covered.[5] In addition, the limitations on the various elements prescribed in the chemical composition of the alloys have been specified more clearly. These changes have been incorporated in the completely revised specifications appended hereto[3] which are recommended for publication as tentative to replace the Standard Specifications B 22 – 21, which standard is to be discontinued as proposed later in this report. The revised specifications are presented as the first step in a program of adjusting specifications for bearing bronzes and bridge plates in accordance with the recommendations of a conference committee composed of representatives of the A.S.T.M., the American Association of State Highway Officials, and the American Railway Engineering Association. It is expected that representatives of these organizations will continue to participate in the development of both cast and wrought metal specifications in this field. It is expected that other alloys may be included in these specifications but their consideration is left for the future.

Proposed Tentative Specifications for Bronze Castings in the Rough for Locomotive Wearing Parts (B 66 – 36 T).—These specifications which are appended hereto[6] have been prepared by Subcommittee II and are recommended for publication as tentative. They represent a revision of and are intended to replace the present Standard Specifications for Bronze Castings in the Rough for Locomotive Wearing Parts (B 66 – 28), which standard is to be discontinued as proposed later in this report. These specifications are identical in substance with the Specifications for Bronze Bearings for Locomotives (M-503-34) of the Association of American Railroads, Mechanical Division.

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[1] See p. 741.
[2] See p. 734.
[3] See p. 724.
[4] 1933 Book of A.S.T.M. Standards, Part I, p. 601.
[5] Additional revisions were submitted at the annual meeting, see Summary of Proceedings, p. 30.—ED.
[6] See p. 728.

Proposed Tentative Specifications for Car and Tender Journal Bearings, Lined (B 36 - 36 T).—These specifications which are appended hereto[1] have been prepared by Subcommittee II and are recommended for publication as tentative. They represent a revision of and are intended to replace the present Standard Specifications for Car and Tender Journal Bearings, Lined (B 67 - 28), which standard is to be discontinued as proposed later in this report. These specifications are identical in substance with the Specifications for Lined Journal Bearings (M-501-34) of the Association of American Railroads, Mechanical Division.

II. Revisions of Tentative Standards.—The committee recommends that the following three tentative specifications be revised[2] as indicated below and continued as tentative:

Tentative Specifications for Copper-Silicon Alloy Plates and Sheets (B 96 - 34 T):[3]

Section 3.—Change this section from its present form: namely,

3. The plates and sheets shall conform to the following requirements as to chemical composition:

Silicon, per cent	1.00 to 5.00
Manganese, max., per cent	1.50
Zinc, max., per cent	5.00
Iron, max., per cent	2.50
Tin, max., per cent	2.00
Aluminum, max., per cent	2.00
Other elements, max., per cent	0.50
Copper, per cent	remainder

to read as follows:

3. (*a*) The plates and sheets shall conform to the following requirements as to chemical composition:

Copper, min., per cent	95
Silicon, per cent	1.00 to 3.75
One or more of the following elements may be present within the limits specified below:	
Manganese, max., per cent	1.50
Zinc, max., per cent	1.75
Iron, max., per cent	1.25
Tin, max., per cent	0.75
Lead, max., per cent	0.05
Sum of above elements, min., per cent	99.50

(*b*) Copper-base alloys containing silicon of generally similar characteristics but with analyses not necessarily coming inside the range given in Paragraph (*a*) may special cases be the subject of agreement between the manufacturer and purchaser, provided the other requirements of these specifications are met.

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[1] See p. 731.

[2] Subsequent to the annual meeting additional revisions of these three specifications were presented to the Society through Committee E-10 on Standards, see Editorial Note, p. 177.—ED.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, p. 692 (1934); also 1935 Book of A.S.T.M. Tentative Standards, p. 348.

Section 5.—Change this section from its present form: namely,

5. The plates and sheets shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb. per sq. in.	55 000
Yield point,[a] lb. per sq. in.	22 500
Elongation in 2 in., per cent	40
Elongation in 8 in., per cent	25

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[a] 0.50 per cent extension under stress.

to read as follows:

5. The plates and sheets shall conform to the following requirements as to tensile properties. Grain size and Rockwell hardness values are given for information only:

	HOT ROLLED	HOT ROLLED COLD ROLLED FINISH	ANNEALED	HALF-HARD
Tensile strength, lb. per sq. in.	55 000 min.	58 000 to 72 000	50 000 to 64 000	71 000 to 81 000
Yield strength,[a] min., lb. per sq. in.	20 000	29 000	18 000	40 000
Elongation in 2 in., min., per cent	50	20	40	10
Grain size, mm	.....	....	0.040 to 0.110	....
Rockwell hardness, "F" scale ($\frac{1}{16}$-in. ball, 60-kg. load)	72 min.	....	72 to 92	....
Rockwell hardness, "B" scale ($\frac{1}{16}$-in. ball, 100-kg. load)	.....	60 to 80	....	79 to 91

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[a] 0.50 per cent extension under stress.

Tentative Specifications for Sheet Copper-Silicon Alloy (B 97 – 34 T):[1]

Section 3.—Make the same change in this section as recommended in Section 3 of Tentative Specifications B 96 – 34 T above.

Section 5 (a).—Change this section from its present form: namely,

5. (*a*) The sheets shall conform to the following minimum requirements as to physical properties:

TEMPER	MATERIAL AND SIZES	TENSILE STRENGTH, LB. PER SQ. IN.	YIELD, POINT,[a] LB. PER SQ. IN.	ELONGATION IN 2 IN., PER CENT	BEND TEST, ANGLE OF BEND, DEG.
Soft	Sheets and strips, all sizes	50 000	......	35.0	180
Half-hard	Sheets and strips up to and including 18 in. in width	70 000	40 000	10.0	120
Hard	Sheets and strips up to and including 18 in. in width	80 000	60 000	5.0	90

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[a] 0.50 per cent extension under stress.

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, p. 699 (1934); also 1935 Book of A.S.T.M. Tentative Standards, p. 355.

to read as follows:

5. (*a*) The sheets shall conform to the following requirements as to tensile properties. Grain size and Rockwell hardness values are given for information only.

TEMPER	TENSILE STRENGTH, LB. PER SQ. IN.	ROCKWELL HARDNESS, "F" SCALE ($\frac{1}{16}$-IN. BALL, 60-KG. LOAD)	ROCKWELL HARDNESS, "B" SCALE ($\frac{1}{16}$-IN. BALL, 100-KG. LOAD)	GRAIN SIZE, mm.
0.070 mm. Anneal	52 000 to 58 000	70 to 82	....	0.050 to 0.1
0.040 mm. Anneal	55 000 to 64 000	76 to 93	....	0.020 to 0.0
Quarter-hard	62 000 to 72 000	....	65 to 80	....
Half-hard	71 000 to 81 000	....	79 to 98	....
Hard	87 000 to 97 000	....	88 to 96	....
Extra-hard	99 000 to 108 000	....	93 to 98	....
Spring	105 000 to 113 000	....	94 to 99	....

Table I.—Replace this table by a table of requirements identical with those shown in Table II of the proposed Tentative Specifications for Sheet and Strip Phosphor Bronze, as appended hereto.[1]

Tentative Specifications for Copper-Silicon Alloy Wire for General Purposes (B 99 – 35 T):[2]

Section 3.—Change this section from its present form: namely,

3. The material shall conform to the following requirements as to chemical composition:

Silicon, per cent	1.00 to 5.00
Manganese, max., per cent	1.50
Zinc, max., per cent	5.00
Iron, max., per cent	2.50
Tin, max., per cent	2.00
Aluminum, max., per cent	2.00
Copper, per cent	remainder
Sum of above elements, min., per cent	99.50

to read as recommended in the new Section 3 of Tentative Specifications B 96 – 34 T above, including the addition of Paragraph (*b*).

Section 5 (a).—Change the table of physical properties appearing in this section from its present form: namely,

TEMPER	GRAIN SIZE, MM.	TENSILE STRENGTH, LB. PER SQ. IN.	BEND
Annealed	0.040 max.[a]	56 000 to 68 000	.....
Quarter Hard[b]	......	75 000 to 88 000	.....
Half Hard[b]	......	90 000 min.	.....
Hard[b]	......	115 000 min.	180 deg. fla
Extra Hard[b] (up to $\frac{3}{8}$ in., incl., only)	......	125 000 min.	around itself
Spring[b] (up to $\frac{1}{4}$ in., incl., only)	......	135 000 min.	around itself

[a] No minimum grain size requirement is specified, but all annealed material shall be fully recrystallized.

[b] The terms "Quarter Hard," "Half Hard," etc., as used here do not necessarily signify reductions of 1, 2, 4, 6 and 8 B. & S. numbers hard as would be the case in coppers or brasses. This is because these specifications permit of a fairly wide range of composition so that the physical properties listed for any given nominal temper might be met by a certain percentage reduction with one alloy and a somewhat different reduction with another alloy, both of which alloys would be within the range of composition permitted.

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[1] See p. 734.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 750 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 359.

to read as follows:

Temper	Physical Properties	Up to 1/8 in., incl., in Diameter	Over 1/8 in. to 1/4 in., incl., in Diameter	Over 1/4 in. in Diameter
Annealed	Grain size, mm	0.015 to 0.040	0.015 to 0.040	0.015 to 0.040
	Tensile strength, lb. per sq. in.	55 000 to 65 000	55 000 to 65 000	55 000 to 65 000
	Elongation[a] in 2 in., min., per cent	42	45	47
	Elongation[a] in 10 in., min., per cent	35	40	[b]
Eighth Hard	Tensile strength, lb. per sq. in.	62 000 to 78 000	62 000 to 78 000	62 000 to 78 000
	Elongation[a] in 2 in., min., per cent	20	25	28
	Elongation[a] in 10 in., min., per cent	18	20	[b]
Quarter Hard	Tensile strength, lb. per sq. in.	72 000 to 85 000	72 000 to 85 000	72 000 to 85 000
	Elongation[a] in 2 in., min., per cent	15	18	20
	Elongation[a] in 10 in., min., per cent	12	15	[b]
Half Hard	Tensile strength, lb. per sq. in., min	90 000	90 000	90 000
	Elongation[a] in 2 in., min., per cent	6	8	10
	Elongation[a] in 10 in., min., per cent	4	6	[b]
Hard	Tensile strength, lb. per sq. in., min	115 000	115 000	115 000
	Elongation[a] in 2 in., min., per cent	4	5	6
	Elongation[a] in 10 in., min., per cent	2	3	[b]
	Bend, min	180 deg. flat	180 deg. flat	180 deg. flat
Spring[c]	Tensile strength, lb. per sq. in., min	135 000	135 000	130 000
	Elongation[a] in 2 in., min., per cent	2	3	4
	Elongation[a] in 10 in., min., per cent	1	1.5	[b]
	Bend, min	Around self	Around self	Around self

[a] Elongation may be determined in either the 2-in. or 10-in. gage length but not in both in any instance.

[b] On wire over 1/4 in. in diameter the percentage of elongation shall be taken in 2 in. only.

[c] The term "Spring Temper" does not necessarily indicate a reduction of 8 B. & S. numbers on these alloy wires as in the case of brass.

III. Proposed Revisions of Standards.—The committee recommends for immediate adoption as standard revisions in the following two specifications and accordingly asks for the necessary nine-tenths vote at the annual meeting in order that these modifications may be referred to letter ballot of the Society for immediate adoption:

Standard Specifications for Aluminum-Bronze Castings (B 59 – 28):[1]

The following changes in these specifications are considered desirable:

Section 2 (d).—Replace this section which reads as follows:

> (*d*) The aluminum shall be that commercially known as Grade No. 1, or that carrying less than 0.30 per cent of silicon. The iron shall be a pure grade of iron free from dirt or other detrimental foreign material.

by the following:

> (*d*) The aluminum used in these castings shall be virgin aluminum of grade 99.0 conforming to the requirements of the Standard Specifications for Aluminum Ingots for Remelting (A.S.T.M. Designation: B 24 – 29) of the American Society for Testing Materials.
>
> (*e*) The iron shall be a pure grade of iron free from dirt or other detrimental foreign material.

Section 3.—In the table of chemical requirements change the present requirement for iron content of Grade B from "not over 1.0 per cent" to read "1.25 per cent, max."

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[1] 1933 Book of A.S.T.M. Standards, Part I, p. 593.

Standard Specifications for Steam or Valve Bronze Sand Castings (B 61 – 28):[1]

Committee B-5 received from the Boiler Code Committee of the American Society of Mechanical Engineers a request that consideration be given to temperature limitation of bronze valves and fittings and to the proper marking of these materials. This matter was referred to Subcommittee II. At the Pittsburgh meeting of Subcommittee II the question of including in the Standard Specifications for Steam or Valve Bronze Sand Castings (B 61 – 28) a statement respecting the temperature limitation and the marking provisions of these bronze castings was referred to a special committee. Subsequent to the meeting, this special committee reported to the acting chairman of Subcommittee II, the following proposed revisions of Specifications B 61:

Section 1.—Change the scope clause to read as follows by the addition of the italicized words and figures and a footnote:

> 1. Scope.—These specifications cover alloy castings, the alloy being a composition of copper, tin, lead, and zinc, commonly used as a high-grade steam metal or valve bronze, *which is suitable for applications involving temperatures*[a] *of 500 F. (260 C.).*
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> [a] The temperature recommendation of the scope clause is conservative in view of known design practice. Establishment of definite limiting design stresses and of dimensional standards later may possibly permit some raising of the limiting temperature above that now recommended.

Section 9.—Change the marking clause from its present form: namely,

> 9. *Marking.*—The castings shall be marked with pattern or mark number, and when practicable with the melt or lot number, at a position on the castings where they will not be machined off in manufacture to finished dimensions.

to read as follows:

> 9. *Marking.*—Valves, flanges and fittings shall be marked in accordance with the Standard Marking System for Valves, Fittings, Flanges and Unions (No. SP-25 – 1936) of the Manufacturers Standardization Society of the Valve and Fittings Industry, and in such position as not to injure the usefulness of the casting.

Since it is considered desirable to incorporate immediately these changes, if approved, in the Standard Specifications B 61, the matter is being submitted to letter ballot of the committee before the June meeting so that the proposed changes can be presented to the Society. These proposed revisions were approved by letter ballot in Subcommittee II with the following results out of a total membership of 28 members: On the revision in Section 1, 11 affirmative, 3 negative and 1 member marked his ballot "not voting"; on the change in Section 9, 12 affirmative, 1 negative and 2 members marked their ballots "not voting." On the completion of this ballot in Subcommittee II, the matter was approved by the chairman of Committee B-5 for inclusion in the report for submission to letter ballot in the main committee. This action has been taken subject to approval by the committee at its June meeting.

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[1] 1933 Book of A.S.T.M. Standards, Part I, p. 608.

The committee further recommends that the revisions proposed in the following two specifications be accepted for publication as tentative:

Standard Specifications for Manganese-Bronze Ingots for Sand Castings (B 7 – 27)[1] and *Standard Specifications for Manganese-Bronze Sand Castings (B 54 – 27)*:[1]

Section 3.—Change the table of chemical requirements appearing in this section to read as follows by the addition of the italicized words and figures and the omission of the figures in brackets:

	Maximum	Minimum
Copper, per cent	[60] *62.0*	55.0
Zinc, per cent	[42] *remainder*	[38] *remainder*
Tin, per cent	1.5	0.0
Manganese, per cent	3.5	[0.0] *0.2*
Aluminum, per cent	1.5	[0.0] *0.5*
Iron, per cent	2.0	[0.0] *0.6*
Lead, per cent	[0.2] *0.4*[a]	0.0

[a] In the case of the Specifications for Castings (B 54) the present requirement for lead is 0.4 per cent; the proposed change is intended to apply only to the lead content requirement in the Specifications for Ingots (B 7).

IV. Adoption of Tentative Standard as Standard.—The committee recommends that the Tentative Specifications for Copper-Base Alloys in Ingot Form for Sand Castings (B 30 – 32 T)[2] be referred to letter ballot of the Society for adoption as standard. The committee has received no recommended changes in these specifications which have now been published as tentative for four years, and it accordingly believes that they should be advanced to the standard status.

V. Adoption of Tentative Revisions of Standards as Standard.—The committee recommends that the tentative revisions proposed in 1934[3] in the following three standards be referred to letter ballot of the Society for adoption as standard:

Standard Specifications for:

Sand Castings of the Alloy: Copper 88 per cent; Tin 8 per cent; Zinc 4 per cent (B 60 – 28),[4]
Steam or Valve Bronze Sand Castings (B 61 – 28),[4] and
Composition Brass or Ounce Metal Sand Castings (B 62 – 28).[4]

The committee wishes to call attention to the fact that with the incorporation of these revisions, which involve changes in chemical composition, in the above specifications the present Section 3 (*b*) will no longer be necessary. It is accordingly proposed to omit this section which reads as follows, this change to be made as an editorial matter:

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[1] 1933 Book of A.S.T.M. Standards, Part I, pp. 616 and 619.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 674 (1932); also 1935 Book of A.S.T.M. Tentative Standards, p. 318.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, pp. 1259, 1260 (1934); also 1935 Book of A.S.T.M. Tentative Standards, pp. 1518, 1519.

[4] 1933 Book of A.S.T.M. Standards, Part I, pp. 589, 608, 612, respectively.

(*b*) Where "none" is specified it shall be construed to refer to none as determined on a 10-g. sample.

VI. Withdrawal of Standards.—The committee recommends the withdrawal of the following three standard specifications which are being replaced by revised tentative specifications as mentioned earlier in this report:

Standard Specifications for:

Bronze Bearing Metals for Turntables and Movable Railroad Bridges (B 22 – 21),[1]
Bronze Castings in the Rough for Locomotive Wearing Parts (B 66 – 28),[1] and
Car and Tender Journal Bearings, Lined (B 67 – 28).[1]

The recommendations appearing in this report have been submitted to letter ballot of the committee which consists of 55 members, the results being as follows:

Items	Affirmative	Negative	Ballots Marked "Not Voting"
I. PROPOSED TENTATIVE STANDARDS			
Specifications for Seamless Copper-Nickel Alloy Condenser Tubes and Ferrule Stock	24	0	11
Specifications for Sheet and Strip Phosphor Bronze	23	0	12
Specifications for Bronze Castings for Turntables and Movable Bridges (B 22 – 36 T)	36	0	9
Specifications for Bronze Castings in the Rough for Locomotive Wearing Parts (B 66 – 36 T)	18	0	17
Specifications for Car and Tender Journal Bearings, Lined (B 67 – 36 T)	19	0	16
II. PROPOSED REVISIONS OF TENTATIVE STANDARDS			
Specifications for Copper-Silicon Alloy Plates and Sheets (B 96 – 34 T)	20	2	13
Specifications for Sheet Copper-Silicon Alloy (B 97 – 34 T)	20	2	13
Specifications for Copper-Silicon Alloy Wire for General Purposes (B 99 - 35 T)	20	2	13
III. PROPOSED REVISIONS OF STANDARDS			
Specifications for Aluminum-Bronze Castings (B 59 – 28), immediate adoption	33	0	12
Specifications for Steam or Valve Bronze Sand Castings (B 61 – 28), immediate adoption:			
Revision in Section 1	34	0	11
Revision in Section 9	24	1	10
Specifications for Manganese-Bronze Ingots for Sand Castings (B 7 – 27)	22	1	12
Specifications for Manganese-Bronze Sand Castings (B 54 – 27)	22	1	12
IV. ADOPTION OF TENTATIVE STANDARD AS STANDARD			
Specifications for Copper-Base Alloys in Ingot Form for Sand Castings (B 30 – 32 T)	26	1	8
V. ADOPTION OF TENTATIVE REVISIONS OF STANDARDS AS STANDARD			
Specifications for Sand Castings of the Alloy: Copper 88 per cent; Tin 8 per cent; Zinc 4 per cent (B 60 – 28)	23	0	12
Specifications for Steam or Valve Bronze Sand Castings (B 61 – 28)	23	0	12
Specifications for Composition Brass or Ounce Metal Sand Castings (B 62 – 28)	24	0	11
VI. WITHDRAWAL OF STANDARDS			
Specifications for Bronze Bearing Metals for Turntables and Movable Railroad Bridges (B 22 – 21)	21	0	14
Specifications for Bronze Castings in the Rough for Locomotive Wearing Parts (B 66 – 28)	21	0	14
Specifications for Car and Tender Journal Bearings, Lined (B 67 – 28)	21	0	14

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Wrought Metals and Alloys (D. K. Crampton, chairman).—In addition to the two new specifications prepared by this subcommittee which are being submitted for publication as tentative, as mentioned earlier in this report, Subcommittee I has in preparation specifications for sheet and strip brass including mixtures outside the range of composition of the materials now specified. It has been found that these will require further consideration before they can be recommended to the main committee. This subcommittee is also working on a revision of the Tentative Specifications for Copper-Silicon Alloy Rods, Bars and Shapes (B 98 - 34 T).

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[1] 1933 Book of A.S.T.M. Standards, Part I, pp. 601, 605, 846, respectively.

Subcommittee II on Cast Metals and Alloys (G. H. Clamer, acting chairman).—This subcommittee has given consideration during the year to the various specifications for castings under its jurisdiction and this has resulted in a number of recommended improvements in the specifications, the adoption of one tentative specification and the revision of three existing standards as mentioned earlier in this report. Subcommittee II is continuing its studies of the chemical and physical requirements of the casting alloys. The subcommittee is not yet ready to recommend a final disposition of the Tentative Specifications for Sand Castings of the Alloy: Copper 80 per cent; Tin 10 per cent; Lead 10 per cent (B 74 - 32 T), which has now been tentative for four years, and it is accordingly recommended that it be continued in this status for another year.

The election of officers for the ensuing term of two years resulted in the re-election of the present incumbents.

This report has been submitted to letter ballot of the committee, which consists of 55 members; 35 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

C. H. MATHEWSON,
Chairman.

D. K. CRAMPTON,
Secretary.

EDITORIAL NOTE

Subsequent to the annual meeting Committee B-5 on Copper and Copper Alloys, Cast and Wrought, presented to the Society on August 26, 1936, through Committee E-10 on Standards revisions in the following four specifications, three of which had also been revised at the annual meeting:

Proposed Revision of Tentative Specifications for:
Copper-Silicon Alloy Plates and Sheets (B 96 - 36 T)
Sheet Copper-Silicon Alloy (B 97 - 36 T)
Copper-Silicon Alloy Rods, Bars and Shapes (B 98 - 34 T)
Copper-Silicon Alloy Wire for General Purposes (B 99 - 36 T).

These recommendations were accepted by Committee E-10 and the specifications n their revised form appear on pp. 744, 751, 747 and 756, respectively.

REPORT OF COMMITTEE B-6
ON
DIE-CAST METALS AND ALLOYS

Committee B-6 on Die-Cast Metals and Alloys has held two meetings during the year, one at Detroit, Mich., on June 26, 1935, and one at Pittsburgh, Pa., on March 5, 1936, with the attendance at the two meetings of 29 and 36, respectively. Certain of the subcommittees have held meetings at various times during the year.

The following additions and changes in membership have been approved:

- Robert W. Waring, Sperry Gyroscope Co., Inc.,
- B. W. Gonser, Battelle Memorial Institute,
- C. H. Greenall, Bell Telephone Laboratories, Inc.,
- W. H. Graves, changed from personal membership to representative of Packard Motor Car Co.,
- J. R. Daesen, Illinois Zinc Co.,
- Henry Lindenberger, U. S. Reduction Co.,
- T. A. Wright, Lucius Pitkin, Inc., and
- Louis W. Blaumann, Michigan Die Casting Co.

At the present time the committee consists of 59 members, of whom 22 are classified as producers, 21 as consumers, and 16 as general interest members.

The exhibit of the work of Committee B-6 which was presented at the 1935 annual meeting was also reserved intact and exhibited at the National Metals Congress at Chicago, Ill., in October, 1935. The committee as a whole wishes to acknowledge its thanks to the chairman of the Exhibit Committee, Mr. H. A. Anderson, to the members of the committee, the Society and the die-casting interests who helped make this exhibit a success.

A sub-subcommittee of Subcommittee I on Aluminum-Base Die-Casting Alloys, consisting of Messrs. D. L. Colwell, R. G. Roshong, D. Basch, W. M. Weil and J. C. Fox, was appointed to consider the desirability of adding alloy No. XI to the Tentative Specifications for Aluminum-Base Alloy Die Castings (B 85 – 33 T), also to make a critical review of the specifications with reference to the desirability of further revision. This sub-subcommittee has submitted to Subcommittee I its recommendations for the omission of alloy No. VI and the addition of alloy No. XI which was included in the original testing program, as well as changes in composition and physical properties and in the wording of the specifications. These recommendations are being referred to letter ballot of Subcommittee I.

The chairman of Subcommittee V on Exposure and Corrosion Tests was authorized to appoint a sub-subcommittee to consider a program of corrosion tests on other alloys and of broadening the scope of its work to include exposures other than atmospheric. This sub-subcommittee will also consider the question of inclusion in this program of magnesium-base alloys and further tests on zinc-base alloys.

The Advisory Committee has drawn up a set of by-laws to cover the procedure of Committee B-6. These by-laws were submitted to letter ballot of the committee, which consists of 59 members, with the following results: 36 affirmative, 0 negative, and 5 ballots marked "not voting."

The sum of $150 was approved by vote of Committee B-6 as its contribution to the expense entailed in the investigative studies being undertaken by the Joint Committee on Exposure Tests of Plating on the Non-Ferrous Metals. This committee consists of representatives of the National Bureau of Standards, the American Electro-Platers' Society and the A.S.T.M.

The tentative draft of the specifications for aluminum alloy ingot for die-casting submitted to the membership of Committee B-6 by Committee B-7 on Light Metals and Alloys, Cast and Wrought, for criticism has been returned to Committee B-7 with comments. Committee B-7 will undertake a revision of the tentative draft to bring the requirements for ingots for die casting in line with the revision which is being made in the specifications for ingots for sand casting.

The following general actions have been taken by the committee:

Subcommittee V on Exposure and Corrosion Tests will undertake exposure tests on zinc-base alloy No. XXIII and an alloy known as Zamak 5, provided that sufficient exposure rack capacity is available. Atmospheric corrosion testing of brass alloys will not be considered for the present. Two magnesium-base alloys, the first, aluminum, max. 10 per cent, silicon, max. 1 per cent, manganese, min. 0.13 per cent and magnesium, remainder; and the second, aluminum, max. 9 per cent, zinc, max. 1 per cent, manganese, min. 0.13 per cent, and magnesium, remainder will be included in the atmospheric exposure tests. Subcommittee V will take up the question of testing types of corrosion encountered in domestic appliances and in equipment handling oil and fuel oil where die-cast alloys are involved.

Subcommittee VI on Finishing Properties of Die Castings has under consideration the question of atmospheric exposure of organic finishes provided exposure facilities for this work are available. Further considerations are being given to the possibility of making total immersion tests in salt water on die castings. It was agreed to lay aside without further consideration the proposal of making soil corrosion tests on die castings.

Specifications Continued as Tentative.—The committee recommends that the Tentative Specifications for Aluminum-Base Alloy Die Castings (B 85 – 33 T), for Zinc-Base Alloy Die Castings (B 86 – 34 T), for Magnesium-Base Alloy Die Castings (B 94 – 34 T), and for Lead and Tin-Base Alloy Die Castings (B 102 – 35 T) be continued as tentative without revision.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Aluminum-Base Die-Casting Alloys (E. E. Thum, chairman).—As mentioned above, the sub-subcommittee under the chairmanship of Mr. Colwell has considered the revision of the Tentative Specifications for Aluminum-Base Alloy Die Castings (B 85 – 33 T) and has submitted to letter ballot its recommendation for the omission of alloy No. VI, the addition of alloy No. XI of the original testing program, and certain changes in composition and physical properties and in the wording of the specifications.

The aluminum alloy die-cast specimens of higher purity than that specified for alloys Nos. IV and V in the Tentative Specifications for Aluminum-Base Alloy Die Castings (B 85 – 33 T) have been tested by the Aluminum Research Laboratories and the Bell Telephone Laboratories after 12, 26 and 52 weeks' exposure to salt spray and after alternate immersion. The data indicate that the alloys of higher purity have superior resistance to attack. The report of this subcommittee appears as Appendix I to this report.

Subcommittee II on Zinc-Base Die-Casting Alloys (C. E. Heussner, chairman).—This subcommittee has undertaken active consideration of an alloy which differs in composition from alloy No. XXI in that its copper content is 1 per cent. It has physical properties intermediate between alloys Nos. XXI and XXIII. The subcommittee is considering the inclusion of this alloy in the Tentative Specifications for Zinc-Base Alloy Die Castings (B 86 – 34 T).

Subcommittee III on Tin- and Lead-Base Die-Casting Alloys (G. O. Hiers, chairman).—This subcommittee is considering changes in its Tentative Specifications for Lead- and Tin-Base Alloy Die Castings (B 102 – 35 T). They also have completed arrangements for analyzing and testing specimens of tin-base and lead-base alloys to determine the physical properties of these alloys. Cooperation is being solicited from the producers for supplying test specimens.

Subcommittee IV on Physical Tests of Die Castings (R. L. Templin, chairman).—Progress has been made on fatigue tests of die castings using specimens of the form used in the R. R. Moore type of rotating-beam machine. Endurance limits determined on the basis of 500 million cycles for some of the aluminum-base alloys covered by the Tentative Specifications for Aluminum-Base Alloy Die Castings (B 85 – 33 T) are as follows:

ALLOY	DESIRED COMPOSITION, PER CENT COPPER	 SILICON	 ALUMINUM	ENDURANCE LIMIT, LB. PER SQ. IN.
No. V	..	12	88	15 000
No. VI	2	3	95	14 500
No. VII	4	5	91	17 000
No. XII	8	1.5	90.5	18 000

No testing problems of importance have come to the attention of the subcommittee during the year but the Section on Speed of Testing of Committee E-1 on Methods of Testing has now decided upon a method of defining speed and it would be desirable for the members of the subcommittee to carry out experimental work on the effects of speed on the results obtained in tension tests of die castings.

Subcommittee V on Exposure and Corrosion Tests (W. M. Peirce, chairman).—A subcommittee has been appointed to consider proposals for extending the work for Subcommittee V to test new alloys following the same plan that has been followed in the original test program and to undertake other types of corrosion testing of these alloys. Additional studies to be undertaken by this subcommittee are mentioned earlier in this report.

Subcommittee VI on Finishing Properties of Die-Castings (J. C. Fox, chairman).—The chairman of this subcommittee has prepared a paper on the subject of "Finishing of Die Castings" which appears in Appendix II to this report.

Subcommittee VII on Magnesium-Base Die-Casting Alloys (J. A. Gann, chairman).—As stated above, this subcommittee has recommended that the Tentative Specifications for Magnesium-Base Alloy Die Castings (B 94 – 34 T) be continued as tentative and that the magnesium-base alloys mentioned above be included in the atmospheric exposure test.

The election of officers for the ensuing term of two years resulted in the re-election of the present incumbents.

This report has been submitted to letter ballot of the committee which consists of 59 members; 49 members returned their ballots, of whom 48 have voted affirmatively.

Respectfully submitted on behalf of the committee,

J. R. TOWNSEND,
Chairman.

P. V. FARAGHER,
Secretary.

APPENDIX I

AN INVESTIGATION OF ALUMINUM DIE-CASTING ALLOYS Nos. IVA AND VA

The initial report of this investigation, describing the preparation of the specimens and presenting the results of chemical analyses and "original" mechanical property tests, was presented in the 1935 annual report of Committee B-6.[1] Since the two materials under investigation were controlled-purity grades of the well-known 5 and 12 per cent silicon alloys, recommended as compositions characterized by an improved resistance to severely corrosive conditions, the corrosion tests of the investigation are its most important features. It is the purpose of this report to present the results of accelerated corrosion tests.

Description

As explained in the previous report, duplicate groups of five specimens of each alloy were exposed for each of three periods to salt-spray tests at two different laboratories and an outdoor alternate immersion test at one laboratory, and were tested after exposure by two laboratories. Unexposed "blanks" were tested with each group of corroded specimens.

Salt-spray tests are used widely enough that they require little description in this report. The Aluminum Research Laboratories and the Bell Telephone Laboratories conducted the exposures; the former using a standard spray tank from a battery in routine service, and the latter employing a special tank assembled for these tests. Both laboratories used a $3\frac{1}{2}$ per cent sodium chloride solution for the spray and operated the tanks at room temperature. In both laboratories, the spray operated essentially continuously for the full period of the investigation. At the Aluminum Research Laboratories, the specimens were supported by inserting about one inch of the lower ends in a wood frame. No attempt was made to distribute the specimens throughout the tank in order to limit variations from differences in corrosive conditions from point to point. At the Bell Telephone Laboratories the specimens were hung from glass rods by means of short lengths of aluminum wire and were arranged so that the two groups of specimens of a given alloy for each period would be subject to comparable attack.

The outdoor alternate immersion test, conducted at the Aluminum Research Laboratories, warrants a brief description. The equipment essentially consists of a large wood tank filled with a $3\frac{1}{2}$ per cent aqueous sodium chloride solution, and a mechanism for alternately immersing the specimens

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 184 (1936).

TABLE I.—INVESTIGATION OF ALUMINUM DIE-CASTING ALLOYS NOS. IVA AND VA, 12 WEEKS 3½ PER CENT SALT-SPRAY TEST.

Alloy	Original Properties			Exposed at Aluminum Research Laboratories			Exposed at Bell Telephone Laboratories		
				Percentage Change			Percentage Change		
	Tensile Strength, lb. per sq. in.	Yield Strength, lb. per sq. in.	Elongation in 2 in., per cent	Tensile Strength	Yield Strength	Elongation in 2 in.	Tensile Strength	Yield Strength	Elongation in 2 in.
TESTED BY ALUMINUM RESEARCH LABORATORIES									
14865 (No. IVa)..	27 135	10 050	6.2	− 9.0	− 6.5	− 9.7	− 5.4	− 2.5	− 3.2
15431..........	25 640	12 400	5.3	− 3.3	− 3.6	−18.9	− 9.0	− 8.5	−20.7
14866 (No. Va)...	32 980	16 250	2.3	+ 0.8	− 0.6	+ 8.7	− 5.3	− 3.1	+13.1
15432..........	29 410	18 150	1.7	− 6.3	+ 2.2	−29.4	−18.8	−11.8	− 5.9
14867 (No. V)....	36 265	18 900	2.5	−30.2	−12.4	−48.0	−24.2	− 5.3	−43.9
15433..........	30 465	19 600	1.5	−26.3[a]	−14.0[a]	−26.7[a]	−13.1	− 9.2	−13.3
TESTED BY BELL TELEPHONE LABORATORIES									
14865..........	28 500	......	4.8	− 3.2	......	+ 5.2	−10.7	......	−11.3
15431..........	27 120	......	3.8	−10.8	......	−10.5	− 3.4	......	− 2.6
14866..........	35 400	......	2.2	−11.9	......	−40.8	− 5.2	......	−31.8
15432..........	29 440	......	1.3	−14.5	......	−25.9	− 1.4	......	−11.1
14867..........	39 010	......	1.6	−26.5	......	−33.3	−41.2	......	−69.8
15433..........	29 860	......	1.0	−13.0	....	0	−35.5	......	−50.0

[a] Average of four specimens.

TABLE II.—INVESTIGATION OF ALUMINUM DIE-CASTING ALLOYS NOS. IVA AND VA, 26 WEEKS 3½ PER CENT SALT-SPRAY TEST.

Alloy	Original Properties[a]			Exposed at Aluminum Research Laboratories			Exposed at Bell Telephone Laboratories		
				Percentage Change			Percentage Change		
	Tensile Strength, lb. per sq. in.	Yield Strength, lb. per sq. in.	Elongation in 2 in., per cent	Tensile Strength	Yield Strength	Elongation in 2 in.	Tensile Strength	Yield Strength	Elongation in 2 in.
TESTED BY ALUMINUM RESEARCH LABORATORIES									
14865 (No. IVa)..	26 955	10 100	5.9	−29.7	−19.8	−32.2	−21.8	−13.9	−28.8
15431..........	26 120	12 450	5.0	−30.2	−22.1	−36.0	−23.3	−16.1	−34.0
14866 (No. Va)...	33 490	16 600	2.9	−21.5	−16.0	−31.0	−22.8	−13.5	−31.0
15432..........	27 655	17 300	1.4	−19.3	−12.7	+14.3	−18.5	− 9.3	− 7.2
14867 (No. V)....	36 715	18 700	2.3	−70.5	−50.8	−60.9	−36.7	−18.2	−30.4
15433..........	28 245	18 700	1.4	−29.3	−21.9	−14.3	−32.3	−11.8	−14.3
TESTED BY BELL TELEPHONE LABORATORIES									
14865..........	29 100	......	5.8	−56.7	......	−58.2	−20.5	......	−28.7
15431..........	27 500	......	4.7	−27.9	......	−34.0	−21.4	......	−34.0
14866..........	35 650	......	2.2	−14.4	......	−11.6	−18.9	......	− 7.0
15432..........	28 760	......	1.3	−14.0	......	−23.1	−15.7	......	−23.1
14867..........	38 620	......	1.6	−79.5	......	−68.8	−27.1	......	−50.0
15433..........	30 260	......	1.5	−51.9	......	−46.6	−28.4	......	−40.0

and exposing them to the atmosphere. The specimens are supported on a counterbalanced aluminum frame (painted) raised and lowered by a clock-controlled motor set to immerse the specimens for 10 min. of each hour. The equipment operates continuously except during the winter (about 4 months) when the solution freezes and the specimens are exposed only to the atmosphere. Specimens for short periods are therefore exposed during the summer months to secure maximum attack.

All corroded specimens of this investigation were cleaned in concentrated nitric acid to remove corrosion products prior to mechanical testing.

TABLE III.—INVESTIGATION OF ALUMINUM DIE-CASTING ALLOYS NOS. IVA AND VA, 52 WEEKS 3½ PER CENT SALT-SPRAY TEST.

Alloy	Original Properties[a]			Exposed at Aluminum Research Laboratories			Exposed at Bell Telephone Laboratories		
				Percentage Change			Percentage Change		
	Tensile Strength, lb. per sq. in.	Yield Strength, lb. per sq. in.	Elongation in 2 in., per cent	Tensile Strength	Yield Strength	Elongation in 2 in.	Tensile Strength	Yield Strength	Elongation in 2 in.
TESTED BY ALUMINUM RESEARCH LABORATORIES									
14865 (No. IVa)..	27 820	10 250	6.3	−73.3	−57.1	−69.8	−28.2	−12.2	−39.7
15431...........	25 740	12 350	4.7	−71.3	−64.3	−74.5	−28.6	−16.2	−38.3
14866 (No. Va)...	33 710	16 800	2.3	−22.8	−14.9	− 4.3	−40.3	−19.1	−34.8
15432...........	28 870	17 900	1.6	−19.2	−13.7	−25.0	−45.0	−30.7	−37.5
14867 (No. V)....	37 400	19 500	2.2	−100	−100	−100	−42.1	−22.6	−40.9
15433...........	30 380	19 600	1.7	−93.4	−89.6	−82.4	−53.3	−41.8	−41.1
TESTED BY BELL TELEPHONE LABORATORIES									
14865 (No. IVa)..	28 500	......	6.3	−44.8	......	−100	−24.5	......	−34.9
15431...........	26 600	......	4.8	−42.8	......	−85.4	−24.8	......	−57.2
14866 (No. Va)...	37 400	......	2.8	−34.2	......	−42.8	−36.6	......	−25.0
15432...........	29 700	......	1.6	......[b]	......	......[b]	−26.9	......	−100
14867 (No. V)....	37 000	......	2.8	−100	......	−100	......[b]	......	......[b]
15433...........	31 500	......	1.5	−100	......	−100	−58.4	......	−100

[a] Bell Telephone Laboratories tests average of 10 specimens.

[b] Data omitted because of marked discrepancies not attributable to exposure conditions.

This procedure was previously investigated by one of the cooperating laboratories and by Subcommittee VIII of the Society's Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys[1] and found to induce negligible changes in weight and mechanical properties.

As already noted, five salt-spray specimens of each alloy from each exposure location and period were tested by the Bell Telephone Laboratories and a like number by the Aluminum Research Laboratories. Similarly, five specimens of each alloy from each period in the outdoor alternate immersion were tested by the Hawthorne Plant of the Western Electric Co.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 163 (1935).

and five by the Aluminum Research Laboratories. All laboratories used Amsler hydraulic testing machines and the testing procedures regularly employed for non-ferrous specimens. Since the testing machines at the Aluminum Research Laboratories are equipped with automatic autographic electrical extensometers, yield strength data were recorded as a matter of routine and have been reported.

TEST RESULTS

The results of the accelerated corrosion tests are summarized in Tables I to X and in Figs. 1 and 2. Tables I to III include the salt-spray data for the three periods. These tables show the properties of the uncorroded "blanks" used by each testing laboratory as the comparison standards and the percentage changes in properties which developed after exposures in the two spray tanks. Tables IV to VI show similar data for the three outdoor alternate immersion periods but, since the exposures were made at only one laboratory, only one set of changes are reported by each testing laboratory. Tables VII to X have been prepared to assist in analyzing the data.

TABLE IV.—INVESTIGATION OF ALUMINUM DIE-CASTING ALLOYS NOS. IVA AND VA, 12 WEEKS OUTDOOR ALTERNATE IMMERSION (3½ PER CENT SEA SALT SOLUTION) TEST.

Alloy	Original Properties			Percentage Change		
	Tensile Strength, lb. per sq. in.	Yield Strength, lb. per sq. in.	Elongation in 2 in. per cent	Tensile Strength	Yield Strength	Elongation in 2 in.
TESTED BY ALUMINUM RESEARCH LABORATORIES						
14865	27 390	9 750	6.7	− 4.6	− 1.5	−10.4
15431	25 960	12 200	4.8	− 3.8	+ 0.8	0
14866	32 825	16 600	2.3	− 1.1	− 4.5	+ 8.0
15432	25 765	16 800	1.5	+ 7.0	+ 4.3	+11.8
14867	36 010	18 950	2.3	−11.4	− 8.1	−13.0
15433	28 345	19 400	1.4	−11.7	− 7.2	−28.6
TESTED BY WESTERN ELECTRIC CO.						
14865	27 800	......	6.8	− 1.1	......	−13.3
15431	25 680	......	4.8	− 4.1	......	− 2.1
14866	33 480	......	2.8	− 3.2	......	−28.6
15432	29 340	......	1.6	− 7.7	......	0
14867	38 560	......	2.3	− 8.1	......	−21.6
15433	27 620	......	1.5	+ 3.5	......	0

DISCUSSION

A detailed discussion of the data in this report does not seem to be justified, but a few pertinent comments may be helpful.

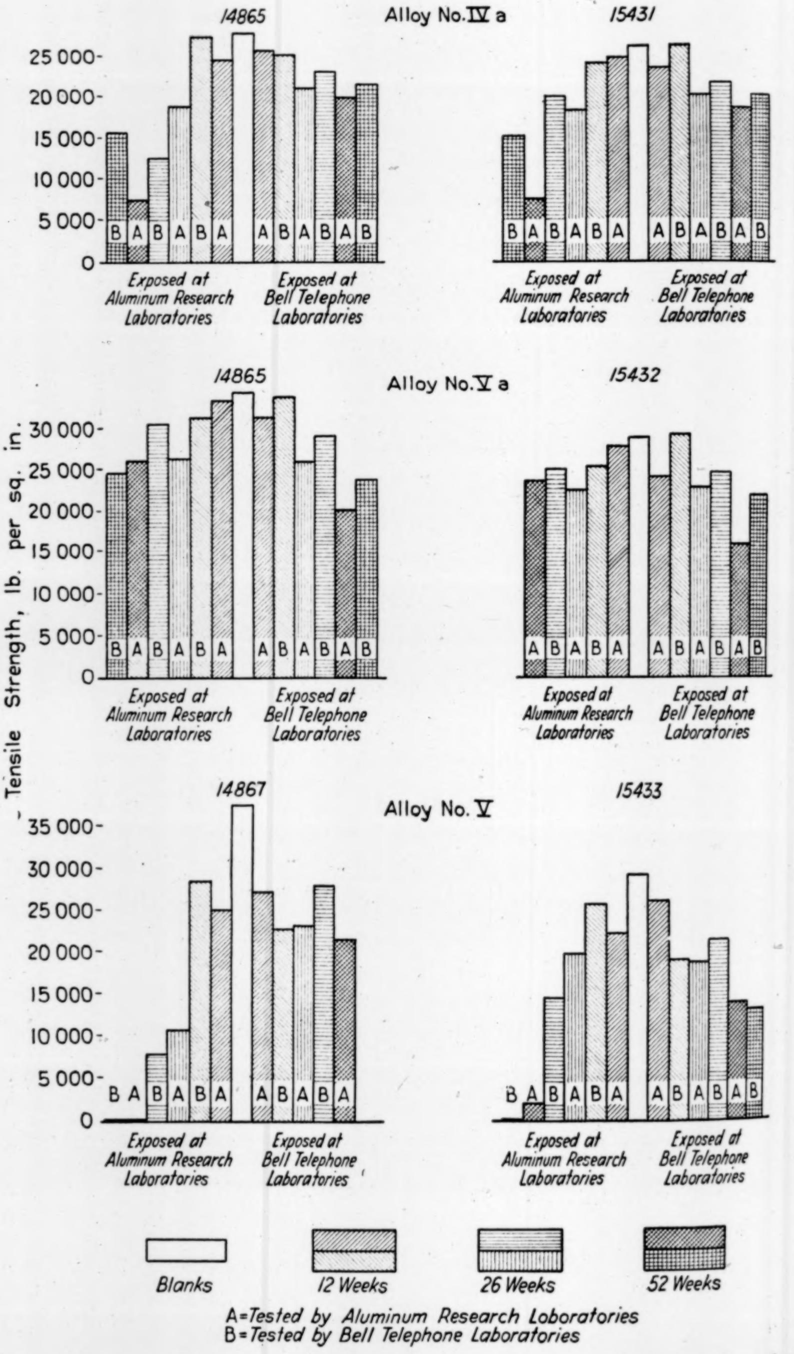

FIG. 1.—Effect of Exposure to the 3½ per cent Salt Spray on the Tensile Strength.

The data of Tables I to III permit estimates of the relative resistance of the several compositions to salt-spray corrosion, of the relative corrosive conditions in the two spray chambers, and of differences in testing procedures. Those of Tables IV to VI, obviously, permit estimates of only the relative resistance to corrosion in the outdoor alternate immersion test and of variations in testing. Since there is inherently some variation both in the mechanical properties of the individual specimens and in their resistance to corrosion, it is believed that the data should be analyzed for trends rather than for numerical differences.

Only a few points in connection with these tables seem to require special note. In Table I, one set of percentage changes represents the average of

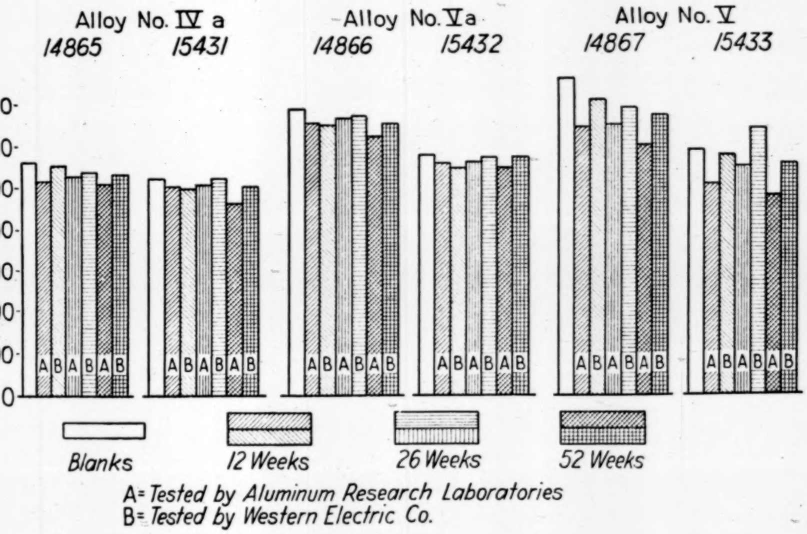

FIG. 2.—Effect of Exposure by Outdoor Alternate Immersion in $3\frac{1}{2}$ per cent Salt Solution on the Tensile Strength.

four specimens because one appeared obviously defective. In Table III the tensile strength of alloy 14866, as determined by the Bell Telephone Laboratories, is markedly higher than all previous averages for this material. A recheck of the data failed to reveal the reason for this apparent discrepancy.

The changes from corrosion shown in Tables I to III appear to vary in a number of cases because of non-uniform uncorroded blanks. Since the several sets of blanks show little evidence of age hardening, determination of *average* original properties for each alloy appears justified, and this has been done in Table VII. The 52 weeks' salt-spray blanks tested by the Bell Telephone Laboratories had not been reported when Table VII was prepared and are not included. Their inclusion would introduce a neg-

TABLE V.—INVESTIGATION OF ALUMINUM DIE-CASTING ALLOYS NOS. IVA AND VA, 26 WEEKS OUTDOOR ALTERNATE IMMERSION (3½ PER CENT SEA SALT SOLUTION) TEST.

Alloy	Original Properties			Percentage Change		
	Tensile Strength, lb. per sq. in.	Yield Strength, lb. per sq. in.	Elongation in 2 in. per cent	Tensile Strength	Yield Strength	Elongation in 2 in.
TESTED BY ALUMINUM RESEARCH LABORATORIES						
14865	27 820	10 350	6.4	− 5.6	− 1.9	− 9.4
15431	26 800	12 800	5.1	− 6.4	− 3.5	−11.8
14866	33 945	16 950	2.5	− 2.6	− 1.8	+ 8.0
15432	28 630	16 850	1.8	− 2.3	+ 2.6	0
14867	37 180	19 500	2.4	−13.2	− 4.1	−16.7
15433	27 965	19 150	1.3	− 2.5	− 2.8	+38.5 (Variable specimens)
TESTED BY WESTERN ELECTRIC CO.						
14865	28 700	......	6.2	− 6.6	......	−19.4
15431	26 000	......	4.7	− 0.8	......	+17.0
14866	34 900	......	2.4	− 4.6	......	− 8.3
15432	29 200	......	1.3	− 2.7	......	+15.4
14867	38 400	......	2.0	−10.9	......	0
15433	30 800	......	1.1	+ 3.2	......	+18.2

TABLE VI.—INVESTIGATION OF ALUMINUM DIE-CASTING ALLOYS NOS. IVA AND VA, 52 WEEKS OUTDOOR ALTERNATE IMMERSION (3½ PER CENT SEA SALT SOLUTION) TEST.

Alloy	Original Properties			Percentage Change		
	Tensile Strength, lb. per sq. in.	Yield Strength, lb. per sq. in.	Elongation in 2 in. per cent	Tensile Strength	Yield Strength	Elongation in 2 in.
TESTED BY ALUMINUM RESEARCH LABORATORIES						
14865 (No. IVa)	27 820	10 250	6.3	− 8.7	− 2.4	− 9.5
15431	25 740	12 350	4.7	−10.9	− 3.6	− 6.4
14866 (No. Va)	33 710	16 800	2.3	− 8.7	− 6.5	+21.7
15432	28 870	17 900	1.6	− 6.4	− 5.3	+12.5
14867 (No. V)	37 400	19 500	2.2	−20.2	− 8.0	−22.7
15433	30 380	19 600	1.7	−21.9	−10.2	−35.3
TESTED BY WESTERN ELECTRIC CO.						
14865 (No. IVa)	28 700	......	6.2	− 8.0	......	− 8.5
15431	26 000	......	4.7	− 4.2	......	+ 2.1
14866 (No. Va)	34 900	......	2.4	− 7.2	......	+16.7
15432	29 200	......	1.3	− 2.7	......	−23.1
14867 (No. V)	38 400	......	2.0	−13.3	......	0
15433	30 800	......	1.1	−10.1	......	− 0.9

ligible change in the averages of all alloys except 14866, where an increase of about 0.8 per cent in tensile strength would result.

Recalculating the changes from corrosion on the basis of these "average blanks" (Tables VIII to X) eliminates practically all of the variations encountered when separate blanks are used.

In all of the tables, the results of corrosion have been expressed as percentage change in mechanical properties. To assist those not accustomed to visualizing data so presented, Figs. 1 and 2 have been prepared. These charts show pictorially the actual tensile strengths after the various exposures and include, as a basis of comparison, the average original strengths (from Table VII). Charts of elongation have not been prepared because these values are relatively low and subject to erratic variations due to testing errors, variations in specimens, and variations in corrosive conditions.

Figure 1 presents the results of the salt-spray tests and indicates that the corrosive conditions in the tank of the Aluminum Research Laboratories were somewhat more severe than those in the Bell Telephone Laboratories' tank, especially as indicated by the results from alloy No. V. Although the two spray tests were standardized to the extent of using the same type and concentration of solution and of operating continuously at room temperature, there are numerous other factors which bear upon the results of such tests. Since no effort was made to have the two tests operate as duplicates, it is not surprising that differences in the results have developed. Their principal importance is as an indication of the differences which might reasonably be expected from salt-spray exposures in various laboratories.

In general, it would appear that the strength of a given alloy after exposure shows but a minor effect from manufacturing variations. For instance, alloy 14865, regardless of where exposed or tested shows about the same strength as alloy 15431 similarly exposed and tested. It is also interesting to note the comparative uniformity of the results reported by the two testing laboratories (A and B). Considering the inherent variations in properties and in resistance to corrosion, both of which might tend toward non-uniform results, the agreements between the two laboratories are gratifyingly close.

Figure 2, summarizing the data from the outdoor alternate immersion test, hardly permits any clean-cut conclusions. In this exposure, the changes in tensile strength are generally within the possible limits of experimental error but, when critically examined, do indicate a superior resistance to corrosion for alloys Nos. IVa and Va as compared to alloy No. V. Even though somewhat less resistant to attack, however, alloy No. V has, in this case at least, a sufficiently higher tensile strength initially that its strength after exposure still equals that of alloy No. Va and exceeds that of alloy

TABLE VII.—SUMMARY OF MECHANICAL PROPERTIES OF "BLANKS" TESTED WITH VARIOUS CORROSION PERIODS.

Average of 5 specimens except where a smaller number is noted (2) (3) (4).

	Tensile Strength, lb. per sq. in.	Yield Strength, lb. per sq. in.	Elongation, in 2 in., per cent	Tensile Strength, lb. per sq. in.	Yield Strength, lb. per sq. in.	Elongation, in 2 in., per cent	Tensile Strength, lb. per sq. in.	Yield Strength, lb. per sq. in.	Elongation, in 2 in., per cent	Tested by[a]
	S 14865			S 14866			S 14867			
12 weeks—Salt-Spray Test	27 135	10 050	6.2	32 980	16 250	2.3	36 265	18 900	2.5	ARL
	28 410		4.7	34 870		1.9	39 050		1.6	BTL
	28 590		5.0	35 930		2.5	38 960		1.7	BTL
26 weeks—Salt-Spray Test	26 955	10 100	5.9	33 490	16 600	2.9	36 715	18 700	2.3	ARL
	29 100		5.8	35 650		2.2	38 620		1.6	BTL
52 weeks—Salt-Spray Test	27 820	10 250	6.3	33 710	16 800	2.3	37 400	19 500	2.2	ARL
12 weeks—Alternate Immersion	27 390	9 750	6.7	32 825	16 600	2.3	36 010	18 950	2.3	ARL
	27 800		6.8(2)	33 480		2.8(2)	38 560		2.3(2)	WE
26 weeks—Alternate Immersion	27 820	10 350	6.4	33 945	16 950	2.5	37 180	19 500	2.4	ARL
	28 660		6.2(3)	34 940		2.4(3)	38 380		2.0(3)	WE
Average	27 968	10 100	6.0	34 182	16 640	2.8	37 714	19 100	2.1	
	S 15431			S 15432			S 15433			
12 weeks—Salt-Spray Test	25 640	12 400	5.3	29 410	18 150	1.7	30 465	19	1.5	ARL
	27 180		4.1	28 390		1.2	29 810		1.0	BTL
	27 060		3.5	30 500		1.5	29 910		1.0	BTL
26 weeks—Salt-Spray Test	26 120	12 450	5.0	27 655	17 300	1.4	28 245	18 700	1.4	ARL
	27 500		4.7	28 769		1.3	30 260		1.5	BTL
52 weeks—Salt-Spray Test	25 740	12 350	4.7	28 870	17 900	1.6	30 380	19 600	1.7	ARL
12 weeks—Alternate Immersion	25 960	12 200	4.8	25 765	16 800	1.5	28 345	19 400	1.4	ARL
	25 680		4.8(4)	29 340		1.6(4)	27 620		1.5(3)	WE
26 weeks—Alternate Immersion	26 800	12 800	5.1	28 630	16 850	1.8	27 965	19 150	1.3	ARL
	26 020		4.7	29 240		1.3(2)	30 800		1.1(4)	WE
Average	26 370	12 450	4.7	28 656	17 400	1.5	29 380	19 290	1.3	

[a] ARL = Aluminum Research Laboratories; BTL = Bell Telephone Laboratories; WE = Western Electric Co.

TABLE VIII.—EFFECT OF EXPOSURE TO $3\frac{1}{2}$ PER CENT SALT SPRAY AT ALUMINUM RESEARCH LABORATORIES FOR PERIODS INDICATED.

Alloy	Percentage Change[a]					
	12 Weeks		26 Weeks		52 Weeks	
	Tensile Strength	Elongation in 2 in.	Tensile Strength	Elongation in 2 in.	Tensile Strength	Elongation in 2 in.
TESTED BY ALUMINUM RESEARCH LABORATORIES						
14865	−11.7	− 6.7	−32.2	−33.3	−73.5	−68.3
15431	− 5.9	− 8.4	−30.8	−31.8	−71.9	−74.5
14866	− 2.8	−10.7	−23.0	−28.6	−23.8	−21.3
15432	− 3.7	−20.0	−22.2	+ 6.8	−18.6	−19.9
14867	−32.9	−38.1	−56.7	−57.2	−100	−100
15433	−23.6[b]	−15.3[b]	−31.9	− 7.8	−93.1	−76.9
TESTED BY BELL TELEPHONE LABORATORIES						
14865	− 1.2	−14.9	−54.9	−60.0	−43.8	−100
15431	− 8.1	−27.7	−23.7	−34.0	−42.4	−85.1
14866	− 8.7	−53.6	−10.6	−20.8	−28.5	−42.8
15432	−12.1	−33.3	−13.6	−33.3	......	......
14867	−23.8	−47.6	−78.9	−76.2	−100	−100
15433	−11.6	−23.1	−50.3	−38.4	−100	−100

[a] Based on average properties shown in Table VII.

[b] Average of 4 corroded specimens.

TABLE IX.—EFFECT OF EXPOSURE TO $3\frac{1}{2}$ PER CENT SALT SPRAY AT BELL TELEPHONE LABORATORIES FOR PERIOD INDICATED.

Alloy	Percentage Change[a]					
	12 Weeks		26 Weeks		52 Weeks	
	Tensile Strength	Elongation in 2 in.	Tensile Strength	Elongation in 2 in.	Tensile Strength	Elongation in 2 in.
TESTED BY ALUMINUM RESEARCH LABORATORIES						
14865 (No. IVa)	− 7.5	0	−24.7	−30.0	−28.5	−36.7
15431	−11.3	−10.6	−24.0	−29.7	−30.2	−38.2
14866 (No. Va)	− 8.7	− 7.1	−24.3	−28.6	−41.2	−46.3
15432	−16.7	+ 6.7	−21.3	−13.3	−44.5	−33.3
14867 (No. V)	−27.2	−33.3	−38.4	−23.7	−42.7	−38.1
15433	− 9.9	0	−34.8	− 7.7	−51.7	−23.1
TESTED BY BELL TELEPHONE LABORATORIES						
14865 (No. IVa)	− 8.9	−28.2	−17.2	−31.7	−23.2	−31.7
15431	− 0.7	−21.2	−18.1	−34.0	−24.2	−74.5
14866 (No. Va)	− 1.7	−46.4	−15.3	−28.5	−30.7	−24.9
15432	+ 1.4	−19.9	−15.3	−33.3	−24.5	−100
14867 (No. V)	−39.2	−76.2	−25.2	−61.9	......	......
15433	−34.4	−61.6	−26.1	−30.8	−55.5	−100

[a] Based on average properties shown in Table VII.

TABLE X.—EFFECT OF EXPOSURE TO $3\frac{1}{2}$ PER CENT SALT SOLUTION BY ALTERNATE IMMERSION OUTDOORS AT ALUMINUM RESEARCH LABORATORIES FOR PERIODS INDICATED.

Alloy	Percentage Change[a]					
	12 Weeks		26 Weeks		52 Weeks	
	Tensile Strength	Elongation in 2 in.	Tensile Strength	Elongation in 2 in.	Tensile Strength	Elongation in 2 in.
TESTED BY ALUMINUM RESEARCH LABORATORIES						
14865	− 6.6	0	− 6.1	− 3.3	− 9.1	− 5.0
15431	− 5.2	+ 2.2	− 4.7	− 4.2	−12.8	− 6.3
14866	− 5.0	−10.7	− 3.2	− 3.6	− 9.9	0
15432	− 3.2	+13.3	− 2.2	+20.0	− 5.7	+20.0
14867	−15.3	− 4.7	−14.3	− 4.7	−20.8	−19.0
15433	−14.8	−23.1	− 7.1	+38.5	−19.1	−15.3
TESTED BY WESTERN ELECTRIC CO.						
14865	− 1.6	0	− 6.3	−16.7	− 5.4	− 3.3
15431	− 6.5	0	− 1.0	+17.0	− 5.5	+ 2.2
14866	− 5.2	−28.6	− 2.7	−21.3	− 5.1	− 3.6
15432	− 5.4	+ 6.7	− 0.7	0	− 1.1	−33.3
14867	− 6.0	−14.3	− 9.2	− 4.7	−11.7	− 4.7
15433	− 2.6	+15.2	+ 8.3	0	− 5.7	−23.1

[a] Based on average properties shown in Table VII.

No. IVa. From the trends shown in the charts, however, it would appear that such a relation would not obtain after a second year in the test.

CONCLUSIONS

Drawing incontrovertible conclusions from the data presented in this report is a somewhat difficult problem because of certain inconsistencies in the data and the natural variability in accelerated corrosion tests with relatively few specimens. The following conclusions, however, are believed to be justified:

1. The resistance of alloy No. Va to salt-spray corrosion, as indicated by losses in tensile strength, is superior to that of either alloy No. IVa or No. V.
2. The resistance of alloy No. Va to salt-spray corrosion does not appear to be as greatly affected by manufacturing differences or variations in exposure conditions as do the resistances of the other two materials.
3. It would appear that the corrosive conditions in the spray tank at the Bell Telephone Laboratories were less severe than those in the tank at the Aluminum Research Laboratories. Since the tests were not planned as duplicates, this difference is not surprising.
4. The reductions in tensile strength caused by exposures to the outdoor alternate-immersion test for up to 52 weeks were generally within the limits of experimental error but do indicate a lower resistance to corrosion for alloy No. V than for alloys Nos. IVa and Va.
5. After exposures in the Bell Telephone Laboratories' salt-spray tank or in the outdoor alternate-immersion apparatus, the strength of alloy No. V is approximately as high as the strength of alloy No. Va, even though the percentage loss, as compared to the original strength, is greater.
6. In general, the results reported by the two testing laboratories for a given material and exposure check reasonably well.
7. The salt spray is a more severe exposure than the outdoor alternate-immersion test used in this investigation.

Respectfully submitted on behalf of Subcommittee I,

E. E. THUM,
Chairman.

APPENDIX II

FINISHING OF DIE CASTINGS

By J. C. Fox[1]

The finishing of die castings is very important from a sales and consumption standpoint. Not only must an article be finished for sales purposes, but the finish must be durable and lasting. The increasing uses of die castings during the past few years have created a demand for better finishing materials, better methods for finishing and inspection of the finish. These demands are being met.

Definite specifications for all types of finishes are gradually replacing the former promiscuous methods of finishing. Most large consumers of die castings now issue specifications covering the type of finish desired, the process to be used in finishing, and the quality of the final finish. To meet these specifications, the finisher must necessarily be more exacting and must carefully control every operation. Chemical control is now found in most large plating shops and even some of the smaller shops have found it highly economical to maintain chemical laboratories and employ chemists to control the plating processes.

The purpose of this paper is to present briefly a review of the present methods used in finishing zinc and aluminum alloy die castings. Only zinc-base and aluminum-base alloy die castings are considered since these two alloys represent about 90 per cent of all die castings consumed. Tin- and lead-base alloy die castings seldom are finished, because in most applications these alloys are used for their corrosion resistance and not for parts requiring decoration. The relatively new copper-base and magnesium-base alloy die castings are not yet of sufficient importance commercially to warrant discussion as to finishing.

ZINC-BASE ALLOY DIE CASTINGS

The standard zinc-base alloys used for die castings are those of the A.S.T.M. Tentative Specifications for Zinc-Base Alloy Die Castings (B 86 - 34 T).[2] Alloy No. XXI is composed essentially of 2.75 per cent copper, 4 per cent aluminum, 0.05 per cent magnesium and the remainder is zinc of special high grade (99.99 + per cent). Alloy No. XXIII is practically the same as alloy No. XXI with the exception that there is no copper in the alloy. Another alloy now being considered by Committee B-6 on Die-Cast Metals and Alloys, which is regularly used, has the same aluminum and magnesium contents and a copper content of 1 per cent.

It is due chiefly to the development of the special high-grade zinc that the consumption of zinc-base die castings has so greatly increased during the past few years. Properly formulated alloys made with this grade of zinc and other raw metals of highest purity are relatively stable, free from intergranular corrosion and structural changes. It is because of these properties that finishes applied to the present type of zinc alloy have greatly advanced in kind, quality and durability. Former zinc-base alloys were subject to rapid corrosion, deterioration and structural changes which greatly lessened the life of any finish applied.

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[1] Chief Chemist and Metallurgist, Doehler Die Casting Co., Toledo, Ohio.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, p. 706 (1934); also 1935 Book of A.S.T.M. Tentative Standards, p. 369.

Most zinc die castings are finished in a variety of ways, both for decoration and protection against tarnishing and surface oxidation. There are, however, many applications, in which zinc die castings are used in the natural as-cast state without any surface treatment. Such parts may be used for long periods of time without any effect on their general utility. It is only when appearance or sales appeal demands, that the present zinc die castings are electroplated or otherwise finished. The corrosion of the present high-purity zinc castings in moist atmospheres is moderate as is shown by the 5-yr. exposure test program conducted by Subcommittee V, of Committee B-6, on Exposure and Corrosion Tests.[1]

The surface oxidation of zinc die castings may be inhibited by the application of a short dip in certain solutions of alkali chromates or dichromates. The New Jersey Zinc Co. has developed an aqueous solution of sodium or potassium dichromate with an addition of a small amount of sulfuric acid. The film formed by dipping zinc die castings into such a solution for 10 to 15 sec. will resist any attack of moisture so long as the dichromate film remains. Zinc-base die-cast carburetors represent an instance of such treatment.

The majority of plated zinc-base die castings for automotive uses are finished in bright nickel or chromium plate. For other uses, they are electroplated with other metals, japanned, enameled, lacquered or finished with a combination of electroplate and enamel. Electric fan bases, clock cases and similar parts are finished in variously colored enamels, with or without high-lighted sections, which may be either chromium plated or the plain zinc alloy polished to a high luster. Polished zinc surfaces, not plated, may be protected against tarnishing by a final coat of a clear synthetic resin varnish.

Realistic wood grain designs may be readily applied to zinc die castings as well as other novelty finishes of a great variety of color, design and texture. Zinc die castings are also being coated with heavy deposits of celluloid mixtures by a dipping process.

ELECTROPLATING

Types of Plating:

Chromium plating, because of its tarnish resistance, high luster and hardness is the most popular finish applied to zinc die castings. Chromium can be applied directly to the metal, but such coatings are porous and lack the necessary protection for the base metal for outdoor exposure. It is common practice to deposit another metal directly to the base metal, which in turn is followed by a finishing coat of chromium. Nickel or the dual plating of copper and nickel have been found most suitable for deposition under chromium.

Extensive experimental work and practical service tests have shown that there is necessary a definite minimum thickness of deposit of this underlying protective metal for each type of application, environment, and condition of use.

There are at present three types of electroplated finishes most generally specified and used, as follows:

1. *Nickel - Chromium Plate:*
   Nickel plate, minimum thickness.............................0.0003 in.
   Chromium plate, minimum thickness.........................0.00001 in.

2. *Nickel - Chromium Plate:*
   Nickel - nickel plate, minimum thickness....................0.0008 in.
   Chromium plate, minimum thickness.........................0.00001 in.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 190 (1935).

3. *Copper - Nickel - Chromium Plate:*

Copper plate, minimum thickness	0.0003 in.
Nickel plate, minimum thickness	0.0003 in.
Total copper and nickel plate, minimum thickness	0.0008 in.
Chromium plate, minimum thickness	0.00001 in.

The type of plating represented by class 1, is the finish mostly applied to zinc die castings such as ornaments, novelties and parts such as those for interior use and not subject to excessive moisture and similar corrosive conditions.

The heavier plated deposits represented by class 2 and class 3 types are applied to zinc die castings subject to outdoor exposure and where a high quality plate is required.

Preparation of the Metal Surface:

There are two important factors which regulate the quality and durability of electrodeposited coatings on zinc die castings: namely, the condition of the surface of the die casting as produced and the proper preparation of the surface for electroplating.

The condition of the die casting surface as cast is very important. Die castings which are to be electroplated must be free from surface porosity, sponginess, deep run-marks, and other similar defects. More care in fabrication and closer inspection must be given die castings to be electroplated than for those parts which are to be otherwise finished. The casting conditions such as gating, venting, pressure, metal and die temperatures must be carefully regulated and maintained to produce the maximum soundness of surface. No electroplated coating can be expected to cover over surface porosity and defects. Early failures of the plate usually results when attempts are made to coat over unsound sections.

Polishing.—Under good casting practice, it is possible to obtain smooth, sound, dense zinc die castings that require little grinding or polishing with coarse abrasives. Castings designed for electroplating finishes should be produced with surfaces sound enough that only a buffing with a rag wheel is required for the significant surfaces which are electroplated. The dense outer-surface characteristic of die castings should be maintained, if at all possible. Gated sections and parting lines necessarily have to be polished on an oil wheel, but on the remainder of the casting it should be only necessary to buff. Of course, this is not always possible, especially on large and intricately shaped castings, but every care should be taken to produce the best casting surface possible as this has a bearing on the ultimate life of the finish.

The oiling operation is usually done on felt or canvas wheels to which is glued emery of mesh varying from 140 to 180, depending upon the amount of surface to be removed.

Buffing is done on a loose, sewed wheel with tripoli as the abrasive and at speeds of 2200 to 3000 r.p.m.

Coloring is done with dry soft-cloth wheels using Vienna lime or a similar compound.

Cleaning.—The cleaning operations on zinc die castings prior to finishing are most important. The casting must be free from grease, buffing compounds, and there must not remain on the surface any film resulting from the cleaning operations.

After the usual polishing and buffing operations, it is essential to clean the castings in an organic solvent to dissolve the binder in the buffing compounds, thereby loosening them for removal by the alkaline cleaning operation. Solvent degreasing effectively removes all oil and grease and loosens the polishing compounds held in the recesses of castings. Following such degreasing treatment, the castings are cathodically cleaned in hot, mild alkaline solutions. Any of the numerous proprietary cleaning compounds can be used provided the concentration of the alkali is kept below the point where the zinc alloy is attacked. The cleaning solutions should be checked and maintained daily.

After suitable alkaline cleaning, the castings must be thoroughly rinsed free from alkali and then dipped into a weak mineral acid solution. Acid solutions such as 5 per cent sulfuric, 5+ per cent hydrochloric, or 1 per cent hydrofluoric are regularly used for this operation. The acid-dip treatment tends to neutralize any free alkali not removed by rinsing, to dissolve any film left from the cleaning operation, and to produce a slightly roughened surface which aids adhesion of the subsequent plate.

Nickel Plating:

In the following table the range of compositions of nickel plating baths most generally used and recommended for electroplating zinc-base alloy die castings are shown:

COMPOSITION	TYPE A	TYPE B
Nickel sulfate, oz	10 to 15	28 to 32
Ammonium chloride, oz	2 to 3	none
Boric acid, oz	2 to 3	4 to 5
Sodium sulfate, oz	12 to 20	none
Nickel chloride, oz	none	3 to 6
Water, gal	1	1
pH value electrometrically	4.9 to 5.7	4.5 to 5.3
colorimetrically	5.4 to 6.2	5.0 to 5.8
Temperature	room to 85 F. (room to 29 C.)	110 to 120 F. (43 to 49 C.
Current densities, amp. per sq. ft.	15 to 30	up to 60
Nickel content, oz	2 to 3	5 to 7

The range of compositions shown under type A is typical of those plating baths regularly used for depositing nickel direct to the zinc-base metal. The high sodium sulfate content permits good conductivity and high "throwing" power, thereby lessening the tendency towards formation of black streaking caused by the precipitation of spongy nickel by immersion. These baths have high efficiency and are relatively easy to control and maintain. Heavy nickel plates from these high sodium-sulfate baths are apt to be hard, brittle and tend towards the formation of stress cracks in the plate.

The type of composition of nickel plating bath represented under type B is similar to the well-known O. P. Watts solution and is used for depositing heavy nickel coats over a previous copper plate or over a nickel "strike" from the high sodium-sulfate bath. This type of solution is used warm, and the deposits resulting are soft and ductile. This solution permits the use of high current densities and deposits heavy nickel plates of desired thicknesses in a minimum time.

Bright Nickel.—A great deal of interest has been shown recently in the possibilities of using bright nickel-plating solutions for deposition of nickel of sufficient luster, to eliminate the necessity for buffing or coloring prior to the deposition of other metals.

There are several types of organic addition agents on the market. These added to a nickel plating bath of composition similar to the type B solution in small amounts yields a plate of high luster. Up to the present only a limited experience has been had with these bright nickel solutions on zinc die castings, but there is a considerable amount of experimental work now being done with them.

Copper Plating:

The plating of copper direct to the zinc base metal is complicated by the tendency of diffusion taking place between the copper plate and zinc-base alloy. Extremely thin deposits of copper may be completely absorbed in relatively short periods of time. Therefore, it is necessary to guard against thin deposits and always specify a minimum thickness of copper. It has been found that a thickness of 0.0002 in. of copper is satisfactory,[1] although it is the practice as a safety measure to specify a minimum thickness of 0.0003 in. Such copper deposits followed by a heavy nickel plate of a minimum thickness of 0.0005 in. will give excellent results provided, of course, that all precautions as to the plating procedure as outlined above are carefully observed.

Copper is plated most generally from a cyanide solution. Most of the standard copper cyanide baths may be used, although one containing appreciable amounts of Roschelle salt is rapidly gaining in favor, due to the fine grained deposits resulting and the ease with which this type of bath is maintained.

A balanced copper cyanide bath containing the proper amount of Roschelle salt produces a copper plate which is fairly bright and does not require buffing or coloring prior to the deposition of nickel plate.

Schedule of Operations:

The following is a typical schedule of operations performed in the electroplating of zinc die castings:

1. Remove parting lines by grinding with 120 to 160 mesh emery glued on a felt or rag wheel, with a speed of wheel of 2200 r.p.m.
2. Polish with 180-mesh emery on a greased felt or rag wheel at 2200 r.p.m.
3. Buff on loose-stitched or bias-sewed canvas wheel using Tripoli at 2200 r.p.m.
4. Degrease in a vapor-phase degreaser using trichlorethylene.
5. Clean in a suitable mild alkaline cleaner, electrolytically at 200 F. (93 C.), making the article the cathode at 6 v. and passing enough current to cause vigorous gassing. Care should be taken to prevent overcleaning. Any of the common cleaning preparations of concentrations of 2 to 4 oz. per gal. may be used.
6. Rinse thoroughly in clear running water.
7. Dip in cold 1 per cent hydrofluoric or 5 per cent sulfuric acid solution for about 30 sec. Rinse in water.
8. Plate in copper bath, current density and time being regulated to produce a plate of minimum thickness of 0.0003-in. copper.
9. Rinse in water.
10. Dip in 5 per cent sulfuric acid solution, rinse.
11. Plate in nickel bath (type B) using sufficient current density and time to produce a plate of minimum thickness of 0.0005-in. nickel, making allowance for subsequent buffing operations.
12. Rinse first in cold then hot water, dry.
13. Color buff nickel plate using Vienna lime.
14. Clean in alkaline electrolytic cleaner.
15. Rinse in water, acid dip and again rinse in water.
16. Plate in chromium solution.

Other Plated Finishes:

In addition to the plated finishes described above, zinc-base die castings may be finished in bronze, silver, gold, and other similar metals. In finishing with these metals it is only essential that a primary coat of nickel of minimum thickness of 0.0001 in. be deposited before electroplating. With this procedure durable finishes will be obtained.

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[1] See W. F. Castell, "A Study of Diffusion on Copper Plated Zinc Base Die Castings," *Transactions*, Electrochemical Soc., Vol. LXVI, pp. 427–440 (1934).

Control of Plating:

Chemical control of the plating room is the best means for securing good uniform deposits of metal. A suggested schedule for the control of plating solutions follows:

All acid dipping solutions should be analyzed every day for acid content. All alkaline cleaners should be checked for carbonate and hydroxide content every day. The copper solutions should be analyzed once a day for copper content, free cyanide and carbonate content. Nickel solutions should be checked twice a week for nickel content, chloride content, sulfate content and boric acid. The pH value of all nickel solutions should be determined twice a day. Additions to the plating solutions should be made immediately upon receiving the analysis. In addition to the above, the thickness of copper and nickel on plated articles should be determined every day. The thickness tests can be arranged so that every piece will have been checked for thickness each week.

To determine the thickness of plating, saw off a sample and fasten it in a clamp so that the surface to be polished will be at right angles to the plated surface. Grind on 120-mesh emery paper until saw marks have been removed. Polish on emery paper No. 1 at right angles to marks left by emery of 120 mesh until scratches have been removed. Polish on emery papers Nos. 0 and 00 in the same way. Polish finally on a broadcloth wheel rotating at 1700 r.p.m. using polishing alumina. Wash off surface between each polishing operation. Etch the sample with $NH_4OH \cdot H_2O_2$ etching solution. Place the sample under a microscope and by means of the scale in the eyepiece, determine the thickness. Three or four samples can be examined at one time by clamping them together. This method is essentially the same as that described by C. E. Heussner[1] who has done a great deal to further the methods and control of electroplating of die castings.

ORGANIC FINISHES

Zinc-base die castings are capable of being finished in a wide variety of organic finishes and combinations of finishes, which are used primarily for decoration and sales appeal. For this purpose, there is available an endless range of colors, and textures in lacquers, enamels, japans, and varnishes. Combinations of lustrous chromium plate with variously colored enamels are being used effectively. Another attractive arrangement is to assemble bright chromium plated zinc die castings with colored plastics, either of the phenolic or cellulose acetate type.

For most applications where enamel finishes are employed, the alloys are not used under conditions of severe outdoor exposure although some types of finishes are capable of such use.

The newer types of baking synthetic resin enamels have almost wholly displaced the use of air-drying pyroxylin lacquers for zinc-base die castings. These new finishes have excellent properties in abrasion resistance, impact strength and extensability. They have unusual adhering qualities, high gloss and are capable of resisting the action of strong chemical solutions, gasoline, oils and the like. They are usually sprayed over surfaces, which have previously been properly prepared, and primed, and are then baked at relatively low temperatures for short intervals of time. The heat of the baking operation changes the resin chemically and makes the finish resistant to heat and insoluble in various media. The baking also aids in binding the enamel to the base coating.

There is little that is standard in the formulation of enamels and lacquers, and compositions vary widely. Each manufacturer has his own particular formula for a given type of finish. For the choice of suitable materials it is, therefore, best to rely upon the integrity and experience of the manufacturer to supply material that is consistently uniform and fulfills all requirements, and to follow the advice and recommendations that he has to offer.

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[1] C. E. Heussner, "Microscopic Measurement of Electroplated Deposits," Monthly Review, Am. Electro-Platers' Soc., January, 1936.

Preparation of the Metal Surface:

As with most finishes on metals, the preparation of the metal surface for the application of organic finishes is most important in the ultimate "life" of the coating. Failure to recognize this may be responsible for poor results. The improved knowledge of the technique of pretreatment of metals for finishing has been a large factor in the increased use and durability of organic finishes on zinc die castings.

To obtain the best results, there are three factors which must be closely observed in the preparation of the metal surface:

1. The metal surface must be thoroughly cleaned free from oil, grease, alkali films and other foreign matter. The choice of the method of cleaning depends upon the nature of the dirt or film to be removed. If an oil film from a previous machining operation is the only foreign matter present, a simple dip in an organic solvent such as carbon tetrachloride, trichlorethylene or similar solvent may suffice to produce a surface clean enough for subsequent treatment. However, cathodic cleaning in a mild alkaline solution such as outlined in the electroplating procedure is relied upon and is generally most effective and economical for cleaning of the metal surface.

2. The work surface should preferably be roughened or etched to provide anchorage and to increase adhesion of the primary coating. Sand-blasting, where available, with a fine sand is effective for this purpose and also serves as an excellent means for cleaning the surface. Etching by chemical means after a previous cleaning operation will also produce a roughened surface. For this, there are several acid solutions which are regularly used; 5 to 10 per cent hydrochloric acid solution, 1 per cent hydrofluoric acid solution; or 3 per cent solution of ortho phosphoric acid may be used with a dip of 20 to 30 sec. followed by a thorough rinsing and drying. There are several proprietary solutions on the market which can be used for this purpose with good results.

3. The use of a suitable priming material applied directly on the base metal is advisable for inhibiting corrosion, insulating the metal surface, resisting penetration by moisture, and acting as a base for succeeding finishing coats. A good primer material properly applied and baked is more important in promoting successful protection of the metal than the quality of finishing coats. Chromate and iron oxide primers suspended in a good synthetic resin vehicle will show excellent corrosion inhibiting qualities. Powdered aluminum in a synthetic resin vehicle can also be used as a primer material for zinc and aluminum die castings.

Enameling:

A typical procedure for enameling zinc die casting is as follows:

1. Clean casting,
2. Sand blast or acid etch,
3. Apply primer coat,
4. Bake primer at about 300 F. (150 C.) for 1 hr.,
5. Apply synthetic resin enamel color coat,
6. Bake enamel, and
7. Add additional color coats as required.

The method of finishing naturally depends to a great extent upon the use and environment to which the article is to be subjected. Some parts, which are not subject to much handling, such as clock cases and ornaments, may require only a good sand blasting and a finishing coat applied without a primer underneath. There are some makes of enamel which can be applied in one coat over a sand-blasted or etched die-cast surface, and which give excellent results. However, a part such as a telephone receiver or base which is handled a great deal requires the best preparation of the surface and a number of finishing coats of enamels to obtain long life.

Combination of Chromium Plate and Enamels:

Some synthetic resin materials are capable of being buffed after baking. Advantage of this is taken in the finishing of ornamental zinc die castings where chromium plate is part of the finish. Such buffing enamels may be applied to the part, baked, the high-lighted parts pumiced, and then such high-lighted parts chromium plated in the regular procedure, without effecting the adhesion of the enamel. Of course, this procedure is used only when there is a large surface to be enameled and only a small section to be plated.

When the reverse is the case, that is, when the electrodeposited coating is the major finish, and only a small section is to be enameled, it is the practice to apply such enamels after first electroplating, and either air dry or bake them at a low temperature. Above temperatures of 250 F. (120 C.) there is a tendency towards blistering of the plating. For this type of finish, the heavy copper-nickel-chromium plating is preferred, since this plating, if properly applied over a sound surface, withstands baking temperatures up to 250 F. (120 C.) more satisfactorily than the direct nickel-chromium coatings.

Selection of Alloy:

For finishing zinc die castings with materials which require the application of heat, some consideration must be given to the composition of the alloy because of the difference of behavior of the standard alloys under heat. A.S.T.M. alloy No. XXI with approximately 3 per cent copper is subject to greater loss of strength, ductility and shock resistance under heat than is alloy No. XXIII with no copper or the alloy having 1 per cent copper. Therefore, for baked finishes, it is recommended that either of the latter two alloys be used in preference to A.S.T.M. alloy No. XXI. These alloys will withstand temperatures up to 350 F. (175 C.) for 2 hr. without any deleterious effects on their physical properties.

Evaluation of Organic Finishes:

There are now available physical test procedures for determining the quality and durability of organic finishes. Details of these tests are set forth in papers by Schuh and his associates[1] who have done excellent work in the development of tests for the quantitative measurement of durability and serviceability of finishes on metals.

ALUMINUM-BASE ALLOY DIE CASTINGS

The standard aluminum base alloys used for die castings are essentially those covered by A.S.T.M. Tentative Specifications for Aluminum-Base Alloy Die Castings (B 85 – 33 T).[2] These alloys, seven in number designated alloys Nos. IV, V, VII, VIII, IX, XI and XII, may be classified into three main groups:

1. Copper-aluminum alloys.
2. Copper-silicon-aluminum alloys.
3. Silicon-aluminum alloys.

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[1] A. E. Schuh, "Evaluation of Industrial Finishes," *Industrial and Engineering Chemistry*, Vol. 23, December, 1931, pp. 1346–1352.

A. E. Schuh and W. Kern, "Measurement of Abrasion Resistance," *Industrial and Engineering Chemistry*, Analytical Edition, Vol. 3, January 15, 1931, pp. 72–76.

A. E. Schuh and H. C. Theurer, "Physical Evaluation of Finishes," *Industrial and Engineering Chemistry*, Analytical Edition, Vol. 6, March 15, 1934, pp. 91–97.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 641 (1933); also 1935 Book of A.S.T.M. Tentative Standards, p. 362.

Light weight, corrosion resistance, ability to take and hold a high polish, and high thermal and electrical conductivity are the desirable properties for which aluminum die castings are noted.

Aluminum die castings are most generally finished by polishing, enameling and anodically oxidizing and coloring. They are seldom electroplated, although this treatment is possible. Special technique and care must be exercised to produce adherent electroplated deposits. The chief difficulty in the electroplating of aluminum-base alloys is in obtaining deposits which will not peel, flake or blister in service. This may be overcome by introducing into the plating procedure a strong acid etch prior to the plating operation. Nickel is used most generally as a primary plate. If a good adherent nickel plate can be deposited, chromium copper, silver, gold and other metals may then be satisfactorily deposited over the nickel. Chromium and zinc can be deposited directly on aluminum-base materials, but such coatings are not very resistant to corrosive conditions.

POLISHING

Polished aluminum die castings retain their luster for long periods of time under ordinary atmospheric conditions. It is because of this that most applications of aluminum die castings are finished simply by polishing and buffing to a high luster. The degree of luster obtained on polishing depends to some extent upon the density of the metal surface. The characteristic dense outer structures found in die castings as a result of the rapid chilling effect promotes high luster in polishing. The usual operations for polishing aluminum die castings to produce a brilliant finish are as follows:

1. Rag Wheel Operation.—This operation employs a wheel made up of buffs to which is glued powdered emery 80 to 120 mesh, with a speed of wheel of about 2500 r.p.m. This operation removes deep scratches, pits, run-marks, etc.

2. Oiling Operation.—For this operation, a solid wheel coated with a finer emery of 140 to 180 mesh is used at about the same speeds as the previous operation.

3. Buffing Operation.—For buffing, the wheel is made up of sewed buffs, the size and shape being determined by the article being treated, with speeds of about 2600 r.p.m.

4. Coloring Operation.—The coloring operation gives to the article a bright mirror finish as a final operation in polishing. It is conducted usually with a 12-in. wheel made up of sections of sewed buffs revolving at a speed of 2000 r.p.m. Vienna lime or similar coloring material are used on the wheels.

Aluminum die castings are also finished in a satin or frosted finish, produced by scratch brushing or by using powdered pumice on the polishing wheels. Ball burnishing is another method regularly used for brightening aluminum surfaces. Still another polished effect known as "Sun-Ray" finish is applied in certain cases, as for example to the inside surfaces of cooking utensils.

Another white frosted finish which is somewhat different in appearance to that obtained by scratch brushing or pumicing, is produced by a strong alkali and strong acid treatment. This treatment, which is used quite extensively for waffle molds, cooking grills and utensils, is briefly described as follows:

ACID DIP TREATMENT

The casting is dipped into a strong hot solution of caustic soda (1 to 2 lb. caustic soda per gallon of water heated to 180 F., 82 C.) until a uniform blackening of the whole casting takes place. It is then rinsed thoroughly in water and then dipped into a strong acid mixture (3 parts concentrated nitric acid, 1 part concentrated hydrofluoric acid) held at room temperature until all the black smudge is dissolved and the casting assumes a white frosted finish throughout.

ENAMELING AND JAPANNING

Japan, an oil enamel made up of gilsonite dissolved in solvents and drying oils, is used quite extensively for finishing many aluminum die castings. The general process is to remove the solvents by heat, and fuse until a uniform hard layer is formed, producing a tough durable finish. Two or three coats are usually applied, the surface being sanded and polished between coats. The cost of the material and process is relatively low and, when properly applied, the finish is durable. Sewing machine, adding machine, and typewriter parts and similar aluminum die-cast parts have japan finishes.

The newer synthetic resin enamels are, however, gradually replacing the japan finish for many parts. This is chiefly due to the superior abrasion and impact resistance and other properties that some of the synthetic enamels possess. The procedure for enameling as outlined for zinc-base die castings can readily be used for aluminum die castings.

ANODIC OXIDATION TREATMENT

One of the methods for finishing aluminum die castings which is gaining rapidly in popularity is the anodic oxidation treatment. By this process, relatively heavy coatings of aluminum oxide are artificially deposited by electrolytic means.

As is well known, there is always present on the surface of aluminum-base metals a very thin natural film of aluminum oxide. This film protects the base metal from attack of corrosive media and is responsible for the ability of aluminum to hold a high polish without tarnishing. Were it not for this protective oxide film, aluminum and its alloys would not have the corrosion resistance they possess. By special means, heavy oxide coatings of approximately 0.0004 in. in thickness can be produced artificially on aluminum surfaces. The best means for accomplishing this is by the anodic oxidation process which consists in making the article to be treated the anode in a suitable electrolyte with a lead lined tank as the cathode. The work is fastened to pure aluminum racks.

Although there are a number of electrolytes suitable for this treatment, the so-called "Alumilite" process, employing a sulfuric acid solution of approximately 25 per cent strength, is commonly used because of certain economies and its general practicability. With the voltage, current density, temperature, and other variables carefully regulated, an extremely tenacious oxide coating is produced which is resistant to moisture, salt solutions, and other corrosive substances. This oxide film is formed of the metal itself and will not chip or flake and is extremely hard and wear resistant. Further, it is quite absorptive, being capable of taking on certain types of aniline dyes and mineral pigments permitting a great variety of coloration. The dyeing of the oxide is done after the oxidation treatment; the article while still on the racks is immersed in a hot aqueous solution of a suitable dye for about 10 min., after which it is removed, rinsed, then dipped into a chemical solution for sealing, and dried. The dyed coating may then be given a very light buffing operation to bring out the luster.

With mineral pigments the range of colors is not so great as with aniline dyes, but they are more durable and fast. They are usually formed by precipitation such as for instance, chrome yellow which may be formed by first dipping the oxide coating in a solution of lead acetate followed by a dip into a soluble chromate solution.

The character of the finished anodically treated article is influenced by the condition of the surface of the article prior to treatment. If a lustrous finish is desired, the article must first be polished. If a matte effect is required, the article may be first sand-blasted before anodizing. Anodic treatment direct on the die-cast surface, as cast, results in a dull oxide coating.

SELECTION OF ALLOY

Protection against staining, corrosion and wear can be given any of the standard aluminum casting alloys. There are, however, some restrictions relative to the alloy most suitable in casting qualities and also for service. When the final appearance of the aluminum die casting after oxidizing is important, the influence of various alloying constituents must be carefully considered.

In the following table the standard A.S.T.M. aluminum die-casting alloys of the Tentative Specifications for Aluminum-Base Alloy Die Castings (B 85 – 33 T)[1] are grouped in order of choice for the anodic oxidation treatment:

ORDER	COLOR AFTER OXIDIZING	CASTING QUALITIES	ABRASION RESISTANCE	CORROSION RESISTANCE	CURRENT REQUIREMENTS
1	VIII	V	VIII	VIII	V
2	XII	XI	IV	IV	IV
3	IV	XII	XI	V	XI
4	XI	IV	V	XI	VIII
5	V	VIII	XII	XII	XII

These selections are based on average results. The order of selection of color is determined by the degree of darkening which takes place in the oxidation treatment. In most alloys, silicon over 1 per cent affects the color. The high-silicon alloys darken badly and are placed at the bottom of the list. Alloy No. VIII gives the lightest in colored oxide. Alloy No. VIII also produces the best combination of hardness and abrasion resistance. Its casting qualities, however, are relatively poor and its use is confined to small and simple-shaped castings.

Alloy No. IV (5 per cent silicon) produces an oxide coating which has good abrasion and corrosion resistance, but the gray appearance may be objectionable for some uses.

Alloy No. V is the best all-around casting alloy, but it produces an oxide coating which is excessively dark in color and low in abrasion resistance.

Alloy No. XII, which is used as a general purpose alloy for die casting, offers a broad scope for colored oxide work. It has fair casting qualities and fair color of the oxide after the anodic treatment which is capable of being dyed in any but the light shades.

The cost of application of the anodic oxidation coating is about the same as the cost of electroplating with nickel. Of course, this will vary with the size, shape and the desired finish, but generally it is relatively an inexpensive finish.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 641 (1933); also 1935 Book of A.S.T.M. Tentative Standards, p. 362.

REPORT OF COMMITTEE B-7

ON

LIGHT METALS AND ALLOYS, CAST AND WROUGHT

Committee B-7 on Light Metals and Alloys, Cast and Wrought has held three meetings since the submission of its report in 1934; one in Philadelphia, Pa., on March 7, 1935, one in Detroit, Mich., on June 27, 1935, and one in Pittsburgh, Pa., on March 5, 1936. A fourth meeting will be held in Atlantic City, N. J., prior to the presentation of this report to the Society.

Since the 1934 annual meeting, the committee has lost two members by resignation and has gained six new members. The membership of the committee now totals 46, of whom 15 are classified as consumer, 22 as producer, and 9 as general interest members.

Committee B-7 has been completely reorganized during the past year in an effort to obtain maximum efficiency in its activities. All existing subcommittees were dissolved, and new subcommittees were authorized and their chairmen appointed. Membership on the various subcommittees is now based on the present interest and activities of the members of the committee. The seven active subcommittees and their chairmen are as follows:

- Subcommittee I on Aluminum and Aluminum Alloy Ingots (D. L. Colwell, chairman)
- Subcommittee II on Aluminum Alloy Castings (C. H. Greenall, chairman)
- Subcommittee III on Aluminum Alloy Wrought Shapes (P. V. Faragher, chairman)
- Subcommittee IV on Magnesium and Magnesium Alloys, Cast and Wrought (J. A. Gann, chairman)
- Subcommittee V on Testing Light Metals (R. L. Templin, chairman)
- Subcommittee VI on Anodic Oxidation of Aluminum and Aluminum Alloys (T. S. Fuller, chairman)
- Subcommittee VII on General Information and Publicity (E. H. Dix, Jr., chairman)

RECOMMENDATIONS AFFECTING STANDARDS

I. Proposed Tentative Standard.—The committee recommends that the proposed Tentative Specifications for Magnesium-Base Alloy Bars, Rods, and Shapes, as appended hereto,[1] be accepted for publication as tentative. These specifications have been prepared in response to a request from the light metal industry.

II. Proposed Revisions of Tentative Standards.—The committee recommends that the following tentative specifications be revised in accordance with the changes shown in the Appendix and that the specifications as revised be continued as tentative. These revisions have been proposed in order that these specifications shall conform with present commercial practice.

Tentative Specifications for:
Magnesium-Base Alloy Sand Castings (B 80 – 34 T),
Magnesium-Base Alloy Sheet (B 90 – 34 T),
Magnesium-Base Alloy Forgings (B 91 – 34 T),
Magnesium Ingot and Stick for Remelting (B 92 – 33 T), and
Magnesium-Base Alloy Ingot for Remelting (B 93 – 34 T).

The recommendations appearing in this report have been submitted to letter ballot of the committee which consists of 46 members, the results being as follows:

Items	Affirmative	Negative	Ballots Marked "Not Voting"
I. PROPOSED TENTATIVE STANDARD			
Specifications for Magnesium-Base Alloy Bars, Rods and Shapes	18	0	6
II. PROPOSED REVISIONS OF TENTATIVE STANDARDS			
Specifications for Magnesium-Base Alloy Sand Castings (B 80 – 34 T)	21	0	3
Specifications for Magnesium-Base Alloy Sheet (B 90 – 34 T)	20	0	4
Specifications for Magnesium-Base Alloy Forgings (B 91 – 34 T)	19	0	5
Specifications for Magnesium Ingot and Stick for Remelting (B 92 – 33 T)	20	0	4
Specifications for Magnesium-Base Alloy Ingot for Remelting (B 93 – 34 T)	20	0	4

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Aluminum and Aluminum Alloy Ingots (D. L. Colwell, chairman) is preparing a revision of the Tentative Specifications for Aluminum-Base Sand-Casting Alloys in Ingot Form (B 58 – 33 T) since the Nonferrous Division of the American Foundrymen's Association requested that there be some latitude in composition tolerances between these ingot specifications B 58 – 33 T and the Tentative Specifications for Aluminum-Base Alloy Sand Castings (B 26 – 33 T). The proposed revision is to be considered by Subcommittee II.

Subcommittee I has likewise been asked to prepare specifications for aluminum alloy ingot for die castings. Action on this problem will await the revision of the Tentative Specifications for Aluminum-Base Alloy Die Castings (B 85 – 33 T) by Committee B-6 on Die-Cast Metals and Alloys.

Subcommittee II on Aluminum Alloy Castings (C. H. Greenall, chairman) is planning to undertake a revision of the Tentative Specifications for

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[1] See p. 720.

Aluminum-Base Alloy Sand Castings (B 26 – 33 T)[1] as soon as Subcommittee I has completed its work on the revision of the Tentative Specifications for Aluminum-Base Sand-Casting Alloys in Ingot Form (B 58 – 33 T). Specifications are likewise being prepared for aluminum-base alloys for permanent mold castings.[2]

A proposed Federal Specification for Aluminum-Base Alloy Castings was discussed and the subcommittee recommended certain changes be suggested to the Federal Board. The subcommittee likewise offered to submit definite recommendations on composition limits to the Federal Board if such were desired.

Subcommittee III on Aluminum Alloy Wrought Shapes (P. V. Faragher, chairman) is reviewing the following specifications for which it is responsible and it is expected that the proposed changes will be completed in time for submission to the committee during the annual meeting:[1]

Tentative Specifications for:

Aluminum Sheet and Plate (B 25 – 34 T),
Aluminum-Alloy (Duralumin) Bars, Rods and Shapes (Aluminum-Copper-Magnesium-Manganese) (B 89 – 33 T),
Aluminum-Manganese Alloy Sheet and Plate (B 79 – 34 T), and
Aluminum-Alloy (Duralumin) Sheet and Plate (Aluminum-Copper-Magnesium-Manganese) (B 78 – 33 T).

This subcommittee was requested to review the Federal Specification for Aluminum-Manganese-Silicon-Chromium Alloy Bars, Rods, and Shapes. The subcommittee suggested an alternative composition with substantially the same physical properties and corrosion resistance and recommended that Committee B-7 take no official action on the subject but refer the question to the two interested producers with the suggestion that they communicate directly with the Federal Board.

Subcommittee IV on Magnesium and Magnesium Alloys, Cast and Wrought (J. A. Gann, chairman) has prepared new proposed Tentative Specifications for Magnesium-Base Alloy Bars, Rods, and Shapes, as appended hereto,[3] and is submitting revisions in the following existing specifications as given in the Appendix:

Tentative Specifications for:

Magnesium-Base Alloy Sand Castings (B 80 – 34 T),
Magnesium-Base Alloy Sheet (B 90 – 34 T),
Magnesium-Base Alloy Forgings (B 91 – 34 T),
Magnesium Ingot and Stick for Remelting (B 92 – 33 T), and
Magnesium-Base Alloy Ingot for Remelting (B 93 – 34 T).

Subcommittee V on Testing Light Metals (R. L. Templin, chairman) has not been responsible for any specific work during the past year but has kept Committee B-7 informed relative to the work of Technical Committee I, of Committee E-1, on Mechanical Testing.

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[1] Subsequent to the annual meeting, Committee B-7 submitted revisions of these specifications to the Society through Committee E-10 on Standards, see Editorial Note, p. 207.—ED.

[2] Subsequent to the annual meeting, Committee B-7 submitted these specifications as tentative to the Society through Committee E-10 on Standards, see Editorial Note, p. 207.—ED.

[3] See p. 720.

Subcommittee VI on Anodic Oxidation of Aluminum and Aluminum Alloys (T. S. Fuller, chairman).—This new subcommittee has been organized to consider specifically the following problems:

1. The requirements of the trade for anodized coatings,
2. Method of testing anodized coatings, and
3. The ability of various anodized coatings to withstand definite service conditions.

Subcommittee VII on General Information and Publicity (E. H. Dix, Jr., chairman) is planning to bring up to date the report entitled "Service Characteristics of the Light Metals and Their Alloys" as submitted in 1934, either by issuing a supplement or by reprinting.

The election of officers for the ensuing term of two years resulted in the re-election of the following:

Chairman, Sam Tour.
Vice-Chairman, E. H. Dix, Jr.
Secretary, J. A. Gann.

This report has been submitted to letter ballot of the committee which consists of 42 members; 24 members returned their ballots, of whom 22 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

SAM TOUR,
Chairman.

J. A. GANN,
Secretary.

EDITORIAL NOTE

Subsequent to the annual meeting Committee B-7 on Light Metals and Alloys, Cast and Wrought, presented to the Society on August 26, 1936, through Committee E-10 on Standards proposed Tentative Specifications for Aluminum-Base Alloy Permanent Mold Castings and a proposed revision of the Tentative Specifications for Aluminum-Base Alloy Sand Castings (B 26 – 33 T). These recommendations were accepted by Committee E-10 and the specifications appear on pp. 669 and 674, respectively.

The following recommendations submitted to the Society by Committee B-7 were accepted by Committee E-10 on November 30, 1936:

Proposed Tentative Specifications for Aluminum-Magnesium-Chromium Alloy Sheet and Plate

Proposed Revision of Tentative Specifications for:

- Aluminum Sheet and Plate (B 25 – 34 T)
- Aluminum-Alloy (Duralumin) Sheet and Plate (Aluminum-Copper-Magnesium-Manganese) (B 78 – 33 T)
- Aluminum-Manganese Alloy Sheet and Plate (B 79 – 34 T)
- Aluminum-Alloy (Duralumin) Bars, Rods and Shapes (Aluminum-Copper-Magnesium-Manganese) (B 89 – 33 T).

The new and revised specifications appear on pp. 699, 685, 690, 694 and 680, respectively.

APPENDIX

PROPOSED REVISIONS IN TENTATIVE STANDARDS FOR LIGHT METALS

In this Appendix are given proposed revisions in certain tentative standards covering light metals and alloys, cast and wrought, which are referred to earlier in this report. In connection with each title is given the reference to the publication in which each specification appears in its present form.

Revision of Tentative Specifications for Magnesium-Base Alloy Sand Castings (A.S.T.M. Designation: B 80 – 34 T):[1]

Section 2 (b).—Change the first sentence of this section to read as follows by the addition of the italicized figure:

> Castings made from Alloys Nos. 1, 2, 3, and *4* may be subjected to such heat treatment as the manufacturer desires to produce material that will conform to the requirements specified.

Section 3.—The following changes are recommended in the table of chemical compositions appearing in this section:

> *Alloy No. 1.*—Change the aluminum content from "7.0 to 9.0 per cent" to read "7.8 to 9.2 per cent."
>
> *Alloys Nos. 1 to 4, inclusive.*—Change the copper content from "0.10 max., per cent" to read "0.05 max., per cent."
>
> *Footnote a.*—Change the maximum nickel content from "0.05 per cent" to read "0.03 per cent."

Section 5.—Change the requirements for Alloy No. 4 in the table appearing in this section by the addition of the following requirements in italics:

ALLOY	CONDITION	TENSILE STRENGTH, MIN., LB. PER SQ. IN.	ELONGATION IN 2 IN., MIN., PER CENT
No. 4	As-cast	24 000	4
	Heat Treatment No. 1[a]	*30 000*	*6*
	Heat Treatment No. 3[c]	*32 000*	*2*

[a] Heat Treatment No. 1—solution heat treatment.
[c] Heat Treatment No 3—solution heat treatment plus complete aging.

Explanatory Note 1.—Change the paragraph for Alloy No. 4 from its present form: namely,

> *Alloy No. 4.*—This alloy has a specific gravity of about 1.84. It is used only in the as-cast condition. Its properties are approximately the same and its resistance to salt-water corrosion is somewhat better than the as-cast Alloy No. 1. The copper and nickel contents should be kept low to minimize corrosion.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, p. 684 (1934); also 1935 Book of A.S.T.M. Tentative Standards, p. 306.

to read as follows:

Alloy No. 4.—This alloy has a specific gravity of about 1.84. It is used in the as-cast, the solution heat-treated (H.T. No. 1), and the solution heat-treated and aged (H.T. No. 3) conditions. Its properties are somewhat better and its resistance to salt-water corrosion is decidedly better than in the case of Alloys Nos. 1 to 3, inclusive. The copper and nickel contents should be kept low to minimize corrosion.

Note 2.—Change the requirements for Alloy No. 4 in the table appearing in this note by the addition of the following requirements in italics:

ALLOY	CONDITION	TYPICAL YIELD STRENGTH (SET = 0.2 PER CENT), LB. PER SQ. IN.	UNIT DEFORMATION, INCH PER INCH OF GAGE LENGTH
No. 4	As-cast	11 000	0.0037
	Heat Treatment No. 1[a]	*11 000*	*0.0074*
	Heat Treatment No. 3[c]	*19 000*	*0.0098*

[a] Heat Treatment No. 1—solution heat treatment.
[c] Heat Treatment No. 3—solution heat treatment plus complete aging.

Revision of Tentative Specifications for Magnesium-Base Alloy Sheet (A.S.T.M. Designation: B 90 – 34 T):[1]

Section 3.—The following changes are recommended in the table of chemical compositions appearing in this section:

Alloy No. 6.—Change the aluminum content from "3.5 to 5.0 per cent" to read "3.3 to 4.7 per cent."

Change the copper content from "0.10 max., per cent" to read "0.05 max., per cent."

Footnote a.—Change the maximum nickel content from "0.05 per cent" to read "0.03 per cent."

Revision of Tentative Specifications for Magnesium-Base Alloy Forgings (A.S.T.M. Designation: B 91 – 34 T):[2]

Section 1.—Change the last sentence of this section by the addition of the italicized word and figure and the omission of the word in brackets:

[Five] *Six* alloys are specified and are designated Alloys Nos. *1*, 6, 7, 8, 9, and 10 (see Explanatory Note 2).

Section 3.—The following changes are recommended in the table of chemical compositions appearing in this section:

Alloy No. 1.—Add Alloy No. 1 to the table, with the following composition:

Magnesium, per cent	remainder
Aluminum, per cent	7.8 to 9.2
Manganese, min., per cent	0.15
Zinc, max., per cent	0.3
Copper, max., per cent	0.05
Tin, per cent	....
Silicon, max., per cent	0.5
Other impurities, max., per cent	0.3

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, p. 688 (1934); also 1935 Book of A.S.T.M. Tentative Standards, p. 310.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, p. 678 (1934); also 1935 Book of A.S.T.M. Tentative Standards, p. 298.

Alloy No. 6.—Change the aluminum content from "3.5 to 5.0 per cent" to read "3.3 to 4.7 per cent."

Alloy No. 7.—Change the aluminum content from "5.0 to 7.0 per cent" to read "5.8 to 7.2 per cent."

Alloy No. 8.—Change the zinc content from "0.5 to 1.0 per cent" to read "0.4 to 1.0 per cent."

Alloys Nos. 6, 7, 8, and 9.—Change the copper content from "0.10 max., per cent" to read "0.05 max., per cent."

Footnote a.—Change the maximum nickel content from "0.05 per cent" to read "0.03 per cent."

Section 5.—Add Alloy No. 1, with the following properties, to the table of physical properties appearing in this section:

ALLOY	TENSILE STRENGTH, MIN., LB. PER SQ. IN.	YIELD STRENGTH, (SET = 0.2 PER CENT), MIN., LB. PER SQ. IN.	ELONGATION IN 2 IN., MIN., PER CENT
No. 1	42 000	24 000	5

Explanatory Notes.—Add the following as the first paragraph under Note 2:

NOTE 2. *Alloy No. 1.*—This alloy has a specific gravity of about 1.80. It can be readily fabricated under a press but cannot be hammer forged. It is stronger than Alloys Nos. 6, 7, 8, and 10 and has about the same mechanical properties as Alloy No. 9. It is sometimes used instead of Alloy No. 9 because it is less susceptible to cracking at elevated temperatures (hot shortness) during fabrication. Its resistance to corrosion is about the same as that of Alloy No. 9.

Add Alloy No. 1, with the following properties, to the table appearing at the end of Note 3:

ALLOY	YIELD STRENGTH (SET = 0.2 PER CENT), MIN., LB. PER SQ. IN.	UNIT DEFORMATION, INCH PER INCH OF GAGE LENGTH
No. 1	24 000	0.0057

Revision of Tentative Specifications for Magnesium Ingot and Stick for Remelting (A.S.T.M. Designation: B 92 – 33 T):[1]

Section 1.—Change the tabulation of requirements on ingot form appearing in Note 1 of this section to read as follows by the addition of the italicized word and figures and the omission of the figures in brackets:

FORM	SIZE AND SHAPE DIAMETER, IN.	LENGTH, IN.	APPROXIMATE WEIGHT, LB.
Ingot (*4 notches*)	[4 by 16] *4 by 4 by 28*		[12.0] *17.0*

Revision of Tentative Specifications for Magnesium-Base Alloy Ingot for Remelting (A.S.T.M. Designation: B 93 – 34 T):[2]

Section 1.—Change Note 1 to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

NOTE 1.—Magnesium-base alloy ingots for remelting are normally furnished in the form of [ingots 4 in. in diameter by 16 in. in length (approximate weight equals

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 636 (1933); also 1935 Book of A.S.T.M. Tentative Standards, p. 302.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, p. 682 (1934); also 1935 Book of A.S.T.M. Tentative Standards, p. 304.

12 lb.] *notched ingots 4 by 4½ by 26½ in. (4 notches) weighing approximately 18 lb.*, unless otherwise specified in the contract.

Add at the end of Note 2 references to the following specifications:

Tentative Specifications for Magnesium-Base Alloy Die Castings (A.S.T.M. Designation: B 94 – 36 T); and for Magnesium-Base Alloy Bars, Rods, and Shapes (A.S.T.M. Designation: B 107 – 36 T).

Section 3.—The following changes are recommended in the table of chemical compositions appearing in this section:

Alloy No. 1.—Change the aluminum content from "7.3 to 8.7 per cent" to read "8.0 to 9.0 per cent."

Alloy No. 6.—Change the aluminum content from "3.6 to 4.8 per cent" to read "3.5 to 4.5 per cent."

Alloy No. 7.—Change the aluminum content from "5.3 to 6.7 per cent" to read "6.0 to 7.0 per cent."

Alloy No. 8.—Change the zinc content from "0.5 to 1.0 per cent" to read "0.4 to 1.0 per cent."

Alloys Nos. 1 to 4 and 6 to 9, inclusive.—Change the copper content from "0.08 max., per cent" to read "0.04 max., per cent."

Alloys Nos. 10 and 11.—Change the copper content from "0.05 max., per cent" to read "0.04 max., per cent."

Alloy No. 12.—Add Alloy No. 12 to the table, with the following composition:

Magnesium, per cent	remainder
Aluminum, per cent	9.4 to 10.6
Manganese, min., per cent	0.13
Zinc., per cent	....
Copper, max., per cent	0.04
Cadmium, per cent	....
Tin, per cent	....
Silicon, max., per cent	1.0
Other impurities, max., per cent	0.3

Footnote a.—Change the maximum nickel content from "0.05 per cent" to read "0.02 per cent."

REPORT OF JOINT COMMITTEE
ON
EXPOSURE TESTS OF PLATING ON THE NON-FERROUS METALS

During the past few years an investigation has been under way on the protective value of various electroplated coatings applied to ferrous metals. This investigation has been reported upon in the National Bureau of Standards *Research Papers Nos. 712*[1], *724*[2] and *867*[3], and has also been referred to in the reports of the A.S.T.M. Committee A-5 on Corrosion of Iron and Steel and in detailed reports in the *Monthly Review* of the American Electro-Platers' Society. A similar investigation has now been undertaken with respect to the value of electroplating on non-ferrous metals. A Joint Committee has been organized consisting of the following, which committee is responsible for the details of conducting this investigation:

Name	Address	Representing
William Blum, chairman	National Bureau of Standards, Washington, D. C.	National Bureau of Standards
W. M. Phillips	General Motors Corp., Detroit, Mich.	American Electro-Platers' Society
Joseph Sexton	Sargent Co., New Haven, Conn.	American Electro-Platers' Society
B. H. McGar	Chase Brass and Copper Co., Inc., Waterbury, Conn.	American Electro-Platers' Society
C. L. Hippensteel	Bell Telephone Laboratories, Inc., New York, N. Y.	American Society for Testing Materials
J. R. Freeman, Jr.	The American Brass Co., Waterbury, Conn.	American Society for Testing Materials
J. C. Fox	Doehler Die Casting Co., Toledo, Ohio	American Society for Testing Materials

General Plan of Exposure Tests

Specimens of various non-ferrous metals, as outlined in the accompanying Table I, have been electroplated as indicated in the succeeding tables and have been exposed at six test locations, utilizing the same test sites as were used for the exposure tests on plated steel specimens. The exposure tests include the continuation of certain specimens from the earlier investiga-

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[1] William Blum, P. W. C. Strausser and Abner Brenner, "Protective Value of Nickel and Chromium Plating on Steel," National Bureau of Standards *Journal of Research*, Vol. 13, No. 3, September, 1934, p. 331.

[2] P. W. C. Strausser, Abner Brenner and William Blum, "Accelerated Tests of Nickel and Chromium Plating on Steel," National Bureau of Standards *Journal of Research*, Vol. 13, No. 4, October, 1933, p. 519.

[3] William Blum, P. W. C. Strausser and Abner Brenner, "Corrosion-Protective Value of Electrodeposited Zinc and Cadmium Coatings on Steel," National Bureau of Standards *Journal of Research*, Vol. 16, No. 2, February, 1936, p. 185.

TABLE I.—COMPOSITION OF BASE METALS.

FERROUS METALS

	Base Metal	Number of Sets	Description of Base Metal	Composition, by Analysis, per cent					Donated by
				Carbon	Manganese	Phosphorus	Sulfur	Silicon	
No. I	Steel	12	Cold-rolled S.A.E. No. 1010[a]	0.10	0.43	0.006	0.017	<0.01	American Steel and Wire Co.
No. II	Steel	2	Full cold-rolled	0.07	0.39	0.013	0.034	<0.01	Stanley Works
No. III	Steel	2	Spring	0.83	0.66	0.023	0.026	0.17	General Spring and Bumper Co.
No. IV	Iron	2	Gray, cast	3.46	0.48	0.64	0.08	2.82	American Stove Co.
No. V	Iron	2	Malleable	1.64	0.27	0.12	0.13	0.93	National Malleable and Steel Casting Co. Polished by Westinghouse Electric and Manufacturing Co.

NON-FERROUS METALS

	Base Metal	Number of Sets	Description of Base Metal	Composition, by Analysis, per cent								Donated by
				Copper	Lead	Tin	Aluminum	Manganese	Nickel	Iron	Zinc	
No. VI	Copper	4	De-oxidized	99.9	...	....	....	....	....	<0.01	....	Revere Copper and Brass, Incorporated.
No. VII	Brass	7	Cast, High A.S.T.M. B 65 – 28[c]	60.9	2.6	1.0	0.32	....	<0.05	<0.05	35.1	Crane Co.
No. VIII	Brass	3	Cast, Low-Ounce Metal A.S.T.M. B 62 – 28[d]	85.4	5.5	4.7	....	....	....	<0.01	4.4	Sargent and Co.
No. IX	Brass	3	Extruded A.S.T.M. B 16 – 29[e]	62.3	2.9	<0.05	....	....	<0.05	<0.1	34.6	Scovill Manufacturing Co.
No. X	Brass	18	Rolled, High A.S.T.M. B 36 – 33[f]	65.7	<0.1	....	....	....	....	<0.01	34.2	Chase Brass and Copper Co., Incorporated.
No. XI	Brass	4	Rolled Low (Alloy L, Committee B-3)[g]	85.0	...	....	....	....	....	<0.01	15.0	Bridgeport Brass Co.
No. XII	Nickel-brass.	5	Rolled (Fed. Spec.)[h]	64.6	...	....	....	0.23	18.2	<0.2	16.8	The American Brass Co.
No. XIII	Nickel-brass.	5	Cast (Fed. Spec.)[h]	66.5	3.7	3.4	....	....	18.9	<0.2	7.2	Standard Sanitary Manufacturing Co.

	Base Metal	Number of Sets	Description of Base Metal	Composition, by Analysis, per cent						Donated by
				Zinc[b]	Copper	Aluminum	Iron	Lead	Magnesium	
No. XIV	Zinc	6	Rolled	98.4	0.99	...	0.017	0.62	....	The New Jersey Zinc Co.
No. XXI	Zinc	7	Die-cast A.S.T.M. Alloy No. XXI[i]	93.8	2.2	4.0	0.009	....	0.02	Doehler Die Casting Co. and The New Jersey Zinc Co.
No. XXIII	Zinc	21	Die-cast A.S.T.M. Alloy No. XXIII[i]	96.1	....	3.9	0.005	....	0.04	Doehler Die Casting Co. and The New Jersey Zinc Co.

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[a] *S.A.E. Handbook*, Soc. Automotive Engrs., 1936 Edition, p. 254.

[b] Zinc was determined by difference.

[c] Standard Specifications for Yellow Brass Sand Castings for General Purposes (A.S.T.M. Designation: B 65), 1933 Book of A.S.T.M. Standards, Part I, p. 597.

[d] Standard Specifications for Composition Brass or Ounce Metal Sand Castings (A.S.T.M. Designation: B 62), 1933 Book of A.S.T.M. Standards, Part I, p. 612.

[e] Standard Specifications for Free-Cutting Brass Rod for Use in Screw Machines (A.S.T.M. Designation: B 16), 1933 Book of A.S.T.M. Standards, Part I, p. 719.

[f] Standard Specifications for Sheet High Brass (A.S.T.M. Designation: B 36), 1933 Book of A.S.T.M. Standards, Part I, p. 728.

[g] Report of Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys, *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 218 (1932).

[h] Federal Specification for Builders' Hardware, Lock and Lock-Trim (FF-H-106).

[i] Tentative Specifications for Zinc-Base Alloy Die Castings (A.S.T.M. Designation: B 86 – 34 T), *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, p. 706 (1934); also 1935 Book of A.S.T.M. Tentative Standards, p. 369.

< = less than.

tion of coatings on steel and some repeat tests on steel specimens, as outlined in the tables. The specimens will be inspected at regular intervals by members of the Joint Committee and other interested individuals.

All of the specimens in these exposure tests are flat plates 4 by 6 in. Most of the rolled metals are of No. 22 gage (0.031 in.) and the cast metals are from 0.1 to 0.2 in. in thickness. The base metals were donated with one side polished. The chemicals and anodes used in plating the specimens were also donated. The specimens were plated at the National Bureau of Standards under controlled conditions so as to produce coatings of uniform quality and known thickness. This work was done by the research associate and research assistant employed by the American Electro-Platers' Society, with considerable assistance from the Bureau staff. Subscriptions to the research fund of the A.E.S. were received from its treasury and from a large number of firms. The cost of mounting the specimens was paid by the A.S.T.M. Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys and Committee B-6 on Die-Cast Metals and Alloys. Information and advice were received from members of the Joint Committee and many other interested persons.

BASE METALS

The test racks in each exposure location provide sufficient space for 112 vertical rows of 5 specimens each. Seven of these rows are used for the retention of specimens started in 1932, and 2 rows are used for holding one unplated specimen of each of the non-ferrous metals in the tests. The remaining 103 rows are used as shown in Table I, which lists the composition and source of each base metal.

METHODS OF PLATING

The solutions and methods of plating were similar to those used in plating the steel specimens and which have been reported in the National Bureau of Standards *Research Papers Nos. 712* and *867*.[1] The detailed conditions of plating, including the composition of each solution, temperature, current density and other essential conditions have been presented in a report to the A.E.S. by P. W. C. Strausser.[2] In general, 12 specimens were plated at one time on two racks of 6 specimens each. During the plating of the zinc specimens and the zinc-base die-casting specimens, the cathode rod was moved mechanically.

The principal materials used in the plating of the specimens are listed in the following table:

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[1] *Loc. cit.*

[2] P. W. C. Strausser, "Observations on the Plating of Non-Ferrous Metals for Outdoor Exposure Tests." Mimeographed *Proceedings*, Convention of Am. Electro-Platers' Soc., 1936; also *Monthly Review*, Am. Electro-Platers' Soc., Vol. 23 (1936). (Copies may be obtained from Mr. W. J. R. Kennedy, Executive Secretary, American Electro-Platers' Society, 90 Maynard St., Springfield, Mass.)

MATERIALS	DONATED BY
Chromic acid	Mutual Chemical Company of America
Sodium cyanide	The R. and H. Chemicals Dept., E. I. du Pont de Nemours and Co., Inc.
Copper cyanide	The R. and H. Chemicals Dept., E. I. du Pont de Nemours and Co., Inc.
Copper sulfate	The Grasselli Chemical Co., Inc.
Sodium sulfate	The Grasselli Chemical Co., Inc.
Nickel sulfate	The Harshaw Chemical Co.
Nickel chloride	The Harshaw Chemical Co.
Anode bags	The Harshaw Chemical Co.
Nickel anodes	The International Nickel Co., Inc.
Buffing compounds	Hanson-Van Winkle-Munning Co.
Buffs	Hanson-Van Winkle-Munning Co.

SCHEDULE OF ELECTRODEPOSITED COATINGS

Coatings on Ferrous Base Metals:

(*a*) *Continuation of Previous Tests.*—At each location where certain of the previously exposed sets of steel specimens have a rating of 3 or better, either 2 or 3 specimens of these sets will be retained on the test racks, as shown in Table II. For details of the preparation of these specimens, see *Research Papers Nos. 712* and *867.*[1]

(*b*) *Repetition of Former Tests.*—The sets shown in Table III were prepared exactly like the corresponding sets and on the same steel (No. 1 Cold-Rolled Steel) as described in *Research Paper No. 712.*[1] The prefix "S" for steel has been inserted to distinguish these coatings from those on other base metals.

(*c*) *Additional Coatings on No. 1 Cold-Rolled Steel.*—Different coatings were applied on the same lot of No. 1 cold-rolled steel as that used in the continuation of the previous tests (Item (*a*), Table II) and in the tests repeated on the former sets (Item (*b*), Table III). These coatings are shown in Table IV.

(*d*) *Coatings on Different Steels and Irons.*—The coatings on the other steel and iron-base metals included in the tests are shown in Table V.

Coatings on Non-Ferrous Base Metals:

(*a*) *Copper and Brass.*—The coatings on the various copper and brass base metals are shown in Table VI.

(*b*) *Zinc and Zinc-Base Die-Castings.*—The coatings on the various zinc and zinc die-cast base metals are shown in Table VII.

EXPOSURE AND INSPECTION

The specimens were mounted on the exposure test racks during April and May, 1936, in the six locations used for the exposure tests of plated steel that were started in 1932; namely, Key West, Fla.; New York, N. Y.; Pittsburgh, Pa.; Sandy Hook, N. J.; State College, Pa.; and Washington, D. C. They will be inspected at regular intervals by members of the Joint Committee and any other interested persons. A schedule of the

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[1] *Loc. cit.*

TABLE II.—COATINGS ON PREVIOUSLY EXPOSED STEEL SPECIMENS.[a]

Set	Coating	Coating Thickness, in.					
		Nickel	Copper	Nickel	Chromium	Zinc	Cadmium
No. 6	Ni[b]	0.002	......	......	......	......	......
No. 16	Ni, Cu, Ni	0.0004	0.0006	0.001	......	......	......
No. 106	Ni, Cr	0.002	......	......	0.00002	......	......
No. 116	Ni, Cu, Ni, Cr	0.0004	0.0006	0.001	0.00002	......	......
No. 154	Ni, Cu, Ni, Cr	0.0002	0.0003	0.0005	0.0001	......	......
No. 206	Zn (cyanide)	......	......	......	......	0.001	......
No. 209	Zn (cyanide + mercury)	......	......	......	......	0.001	......
No. 215	Zn (high SO_4)	......	......	......	......	0.001	......
No. 218	Zn (dextrin)	......	......	......	......	0.001	......
No. 219	Zn (hot dip)	......	......	......	......	0.0009	......
No. 305	Cd (cyanide)	......	......	......	......	......	0.001
No. 309	Cd (cyanide + gulac)	......	......	......	......	......	0.001
No. 312	Cd (cyanide + gulac + Ni)	......	......	......	......	......	0.001
No. 403	Zn 90 per cent, Cd 10 per cent	......	......	......	......	Zinc + Cadmium 0.001	

[a] All coatings were plated on No. 1 cold-rolled steel.

[b] Except as noted, all final nickel coatings were buffed, whether or not they were chromium plated.

TABLE III.—COATINGS ON STEEL SPECIMENS USED IN REPETITION OF FORMER TESTS.[a]

Set	Coating	Coating Thickness, in.				Variation
		Nickel	Copper	Nickel	Chromium	
No. S 1	Ni	0.001	......	......	......	Standard[b] nickel
No. S 101	Ni, Cr	0.001	......	......	0.00002	Standard[b] nickel, chromium
No. S 102	Ni, Cr	0.001	......	......	0.00002	Cathode pickle
No. S 106	Ni, Cr	0.002	......	......	0.00002	Thickness nickel
No. S 113	Ni, Cu (acid), Ni, Cr	0.0002	0.0003	0.0005	0.00002	Acid copper layer
No. S 114	Ni, Cu (cyanide), Ni, Cr	0.0002	0.0003	0.0005	0.00002	Cyanide copper layer
No. S 116	Ni, Cu (acid), Ni, Cr	0.0004	0.0006	0.001	0.00002	Acid copper layer

[a] All coatings were plated on No. 1 cold-rolled steel; and all final nickel layers were buffed.

[b] The term "standard" in this and succeeding tables refers merely to a procedure used as a basis of comparison and does not imply superiority.

TABLE IV.—ADDITIONAL COATINGS ON COLD-ROLLED STEEL NO. 1.

Set	Coating	Coating Thickness, in.				Variation
		Nickel	Copper	Nickel	Chromium	
No. S 171	Ni, Cu (cyanide), Ni, Cr	0.0002	0.0005	0.0003	0.00002	Final nickel thinner than No. S 114
No. S 172	Ni, Cr	0.001	......	......	0.00005	Chromium thicker than No. S 101
No. S 173	Ni, Cr	0.001	......	......	0.0001	Chromium thicker than No. S 172
No. S 174	Ni, Cr	0.002	......	......	0.0001	Chromium thicker than No. S 106
No. S 175	Ni, Cr	0.001	......	......	0.00002	Nickel with air agitation

TABLE V.—COATINGS ON BASE METALS OF DIFFERENT STEELS AND IRONS.

Set	Description of Base Metal	Coating	Coating Thickness, in.				Variation
			Nickel	Copper	Nickel	Chromium	
No. S 181	Cold-rolled steel, No. II	Ni, Cr	0.001	......	......	0.00002	Standard
No. S 182	Cold-rolled steel, No. II	Ni, Cr	0.001	......	......	0.00002	Cathode pickle
No. S 191	Spring steel, No. III	Ni, Cr	0.001	......	......	0.00002	Standard
No. S 192	Spring steel, No. III	Ni, Cu (cyanide), Ni, Cr	0.0002	0.0003	0.0005	0.00002	Cyanide copper layer
No. I 1	Gray iron, No. IV	Cu[a] (cyanide), Ni, Cr	......	0.00005	0.002	0.00002	Copper flash
No. I 2	Gray iron, No. IV	Cu[a] (cyanide), Ni, Cr	......	0.001	0.001	0.00002	Thick copper
No. I 3	Malleable iron, No. V	Cu[a] (cyanide), Ni, Cr	......	0.00005	0.002	0.00002	Copper flash
No. I 4	Malleable iron, No. V	Cu[a] (cyanide), Ni, Cr	......	0.001	0.001	0.00002	Thick copper

[a] These coatings were buffed.

TABLE VI.—COATINGS ON COPPER AND BRASS BASE METALS.

Set	Coating	Coating Thickness, in.			Variation
		Copper	Nickel	Chromium	
ON COPPER (No. VI)					
No. C 1	Ni, Cr	....	0.0002	0.00002	Standard
No. C 2	Ni, Cr	....	0.0005	0.00002	Thickness nickel
No. C 3	Ni, Cr	....	0.0005	0.00002	Citrate anodic etch
No. C 4	Cr[a]	....	....	0.0002	Direct chromium
ON CAST HIGH BRASS (No. VII)					
No. B 1	Ni, Cr	....	0.0002	0.00002	Standard
No. B 2	Ni, Cr	....	0.0001	0.00002	Thickness nickel
No. B 3	Ni, Cr	....	0.0005	0.00002	Thickness nickel
No. B 4	Ni, Cr	....	0.0002	0.00001	Thickness chromium
No. B 5	Cu (cyanide), Ni, Cr	0.00005	0.0002	0.00002	Copper flash
No. B 6	Ni, Cr	....	0.0002	0.00002	H_2SO_4 anodic etch
No. B 7	Cr[a]	....	....	0.0002	Direct chromium
ON CAST LOW BRASS (No. VIII)					
No. B 11	Ni, Cr	....	0.0002	0.00002	Standard
No. B 13	Cu (cyanide), Ni, Cr	0.00005	0.0002	0.00002	Copper flash
No. B 14	Cr[a]	....	....	0.0002	Direct chromium
ON EXTRUDED BRASS (No. IX)					
No. B 21	Ni, Cr	....	0.0002	0.00002	Standard
No. B 23	Cu (cyanide), Ni, Cr	0.00005	0.0002	0.00002	Copper flash
No. B 24	Cr[a]	....	....	0.0002	Direct chromium
ON ROLLED HIGH BRASS (No. X)					
No. B 31	Ni, Cr	....	0.0002	0.00002	Standard
No. B 32	Ni, Cr	....	0.0001	0.00002	Thickness nickel
No. B 33	Ni, Cr	....	0.0002	0.00003	Thickness chromium
No. B 34	Ni, Cr	....	0.0005	0.00002	Thickness nickel
No. B 35	Ni, Cr	....	0.0002	0.00001	Thickness chromium
No. B 36	Ni, Cr	....	0.0003	0.00002	Thickness nickel
No. B 37	Ni, Cr	....	0.0002	0.00005	Thickness chromium
No. B 38	Ni	....	0.0002	....	No chromium
No. B 39	Cr	....	....	0.00003	Direct chromium, thin
No. B 40	Cu (cyanide), Ni, Cr	0.00005	0.0002	0.00002	Cyanide copper flash
No. B 41	Cu (acid), Ni, Cr	0.00005	0.0002	0.00002	Acid copper flash
No. B 42	Ni, Cr	....	0.0002	0.00002	Nickel not buffed
No. B 43	Ni, Cr	....	0.0002	0.00002	Citrate anodic etch
No. B 44	Cr[a]	....	....	0.0002	Direct chromium, thick
No. B 45	Ni, Cr	....	0.0002	0.00002	H_2SO_4 anodic etch
No. B 46	Ni, Cr	....	0.0002	0.00002	Low pH nickel
No. B 47	Ni, Cr	....	0.00005	0.00002	Thickness nickel
No. B 48	Ni, Cr	....	0.0002	0.00002	Nickel with air agitation
ON ROLLED LOW BRASS (No. XI)					
No. B 51	Ni, Cr	....	0.0002	0.00002	Standard
No. B 53	Cr[a]	....	....	0.0002	Direct chromium
No. B 54	Ni, Cr	....	0.0002	0.00002	H_2SO_4 anodic etch
No. B 55	Ni, Cr	....	0.0002	0.00002	H_2SO_4 anodic etch, low pH nickel
ON ROLLED NICKEL BRASS (No. XII)					
No. N 1	Cr[a]	....	....	0.0002	Direct chromium
No. N 2	Cr	....	....	0.0001	Thickness chromium
No. N 3	Cr	....	....	0.00005	Thickness chromium
No. N 4	Ni, Cr	....	0.0001	0.0001	Thickness nickel and chromium
No. N 5	Ni, Cr	....	0.0002	0.00002	Standard
ON CAST NICKEL BRASS (No. XIII)					
No. N 11	Cr[a]	....	....	0.0002	Direct chromium
No. N 12	Cr[a]	....	....	0.0001	Thickness chromium
No. N 13	Cr[a]	....	....	0.00005	Thickness chromium
No. N 14	Cu (cyanide), Ni, Cr	0.00005	0.0002	0.00002	Copper flash
No. N 15	Ni, Cr	....	0.0002	0.00002	Standard

[a] These coatings were buffed.

inspection dates, and any other information desired regarding these tests will be furnished on request addressed to the chairman of the Joint Committee, Mr. William Blum, National Bureau of Standards, Washington, D. C.

TABLE VII.—COATINGS ON BASE METALS OF ZINC AND ZINC-BASE DIE CASTINGS.

S=Standard nickel bath.
HS=High sulfate nickel bath.

Set	Coating	Coating Thickness, in.			Variation
		Copper	Nickel	Chromium	
ON ROLLED ZINC (No. XIV)					
No. Z 1	Ni (HS), Cr	......	0.0005	0.00002	Standard
No. Z 2	Ni (HS), Cr	......	0.0003	0.00002	Thickness nickel
No. Z 3	Ni (HS), Cr	......	0.0005	0.00003	Thickness chromium
No. Z 4	Ni (HS), Cr	......	0.0005	0.00001	Thickness chromium
No. Z 5	Ni (HS), Ni (S), Cr	......	0.0002 0.0003	0.00002	"Duplex" nickel
No. Z 6	Cu (cyanide), Ni (S), Cr	0.0002	0.0003	0.00002	Copper layer
ON ZINC DIE CASTINGS (ALLOY No. XXI)					
No. Z 11	Ni (HS), Cr	......	0.0005	0.00002	Standard
No. Z 12	Ni (HS), Ni (S), Cr	......	0.0002 0.0003	0.00002	"Duplex" nickel
No. Z 13	Ni (HS), Ni (S), Cr	......	0.0002 0.0008	0.00002	"Duplex" nickel thickness
No. Z 14	Cu (cyanide), Ni (S), Cr	0.0002	0.0003	0.00002	Copper layer
No. Z 15	Cu (cyanide), Ni (S), Cr	0.0001	0.0009	0.00002	Thickness copper, nickel
No. Z 16	Cr[a]	......	......	0.0001	Direct chromium, cold
No. Z 17	Ni (HS), Cr	......	0.001	0.00002	Thickness nickel
ON ZINC DIE CASTINGS (ALLOY No. XXIII)					
No. Z 19	Ni (HS)	......	0.0005	....	Standard nickel
No. Z 20	Ni (HS)	......	0.0003	....	Thickness nickel
No. Z 22	Ni (HS), Cr	......	0.0005	0.00002	Standard nickel, chromium
No. Z 24	Ni (HS), Cr	......	0.0003	0.00002	Thickness nickel
No. Z 25	Ni (HS), Cr	......	0.0005	0.00001	Thickness chromium
No. Z 26	Ni (HS), Cr	......	0.0005	0.00003	Thickness chromium
No. Z 31	Cr[a]	......	......	0.0001	Direct chromium, hot
No. Z 33	Cr[a]	......	......	0.0001	Direct chromium, cold
No. Z 35	Ni (HS), Ni (S), Cr	......	0.0002 0.0003	0.00002	Standard "Duplex" nickel
No. Z 36	Ni (HS), Ni (S), Cr	......	0.0002 0.0003	0.00001	Thickness chromium
No. Z 37	Ni (HS), Ni (S), Cr	......	0.0002 0.0008	0.00002	Thickness nickel
No. Z 38	Ni (HS), Ni (S), Cr	......	0.0002 0.0018	0.00002	Thickness nickel
No. Z 40	Cu (cyanide), Ni (S), Cr	0.0002	0.0003	0.00002	Standard copper, nickel, chromium
No. Z 41	Cu (cyanide), Ni (S), Cr	0.0004	0.0006	0.00002	Thickness copper, nickel
No. Z 42	Cu[a] (cyanide), Ni (S), Cr	0.0005	0.0015	0.00002	Thickness copper, nickel
No. Z 43	Cu (cyanide), Ni (S), Cr	0.0003	0.0002	0.00002	Ratio copper/nickel
No. Z 45	Ni (HS), Cu (cyanide), Ni (S), Cr	0.0002	0.0003 0.0005	0.00002	Inter. copper layer
No. Z 47	Ni (HS), Cr	......	0.001	0.00002	Thickness nickel
No. Z 48	Ni (HS), Cr	......	0.0003	0.00002	Thickness nickel
No. Z 49	Cu[a] (cyanide), Ni (S), Cr	0.0005	0.00075	0.00002	Thickness copper, nickel
No. Z 50	Cu[a] (cyanide), Cr[a]	0.0005	......	0.0002	Chromium over copper

[a] These coatings were buffed.

Respectfully submitted on behalf of the Joint Committee,

WILLIAM BLUM,
Chairman.

REPORT OF COMMITTEE C-1
ON
CEMENT

Committee C-1 on Cement has held two well attended meetings during the year. Although but two recommendations are presented immediately affecting standards with which the committee is concerned, active work and discussions have been in progress covering the various phases of its activities.

High-Early-Strength Cements:

The committee recommends that the Tentative Specifications for High-Early-Strength Portland Cement (C 74 – 30 T) be revised by the use of a new definition, by the insertion of optional compressive strength requirements and a fineness requirement prescribing a specific surface of not less than 1900 sq. cm. per gram of cement. The detailed changes have been incorporated in the revised specifications which are appended hereto.[1] These recommended revisions are proposed only after several years of study by the Sponsoring Committee on High-Early-Strength Cement (M. A. Swayze, chairman), and by cooperating laboratories. The committee further recommends that these Tentative Specifications C 74 – 30 T, revised in accordance with the preceding recommendation, be referred to letter ballot of the Society for adoption as standard. This recommendation is made in order to meet a demand for a standard specification to cover purchases of high-early-strength portland cement.

The committee also recommends for publication as tentative the proposed Tentative Specifications for High-Early-Strength Treated Portland Cement, appended hereto.[2] These specifications differ in definition alone from the Tentative Specifications for High-Early-Strength Portland Cement (C 74). This recommendation is made because of a demand which has existed for some time for specifications to cover those high-early-strength portland cements which contain certain additions not permitted by the definition in Specifications C 74.

Masonry Cements:

The committee is recommending the continuation for another year without change of the Tentative Specifications and Tests for Masonry

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[1] These specifications were further revised at the annual meeting, see Summary of Proceedings, p. 20, and subsequently adopted as standard. The specifications in their revised form appear in the 1936 Book of A.S.T.M. Standards, Part II, p. 4.—Ed.

[2] At the annual meeting, see Summary of Proceedings, p. 21, Committee C-1 withdrew its recommendation for publication as tentative of the Specifications for High-Early-Strength Treated Portland Cement in view of the changes made in the Specifications for High-Early-Strength Portland Cement (A.S.T.M. Designation: C 74) to provide for treated cements. This action was approved by letter ballot of the committee, which consists of 72 members; of the $65\frac{2}{3}$ ballots returned, the results were as follows: Affirmative $59\frac{2}{3}$, negative 4, and ballots marked "not voting" 2.—Ed.

Cement (C 91 – 32 T). As indicated in last year's report, there is a marked desire upon the part of those using these specifications to have it continued in its present status. It is being used in purchasing, notwithstanding its lack of requirements for such qualities as plasticity, ability to retain water when in contact with rapidly absorbing units, etc. Unfortunately, the committee does not yet have tests for these properties which it wishes to advocate; hence the recommendation to continue these specifications as tentative for another year.

The Sponsoring Committee on Masonry Cement (H. D. Baylor, chairman) has given consideration to a revision of the Society's Standard Specifications for Natural Cement (C 10 – 09). A draft of such a revision has been made and is being studied by interested purchasers and consumers.

Blended Cements:

The Subcommittee on Blended Cements (R. E. Roscoe, chairman) presented at the last meeting of the committee very interesting proposed specifications for cements of this type. These specifications contain a number of features which will require their intensive study. This is being inaugurated at the present time and it would appear that in the course of the next year the specifications should be available for publication as tentative. It should be stressed, however, that since such cements may be composed of a wide variety of materials, adequate specifications will need to receive rather mature consideration, particularly since the specifications should contain requirements rather more stringent than those applied to material like portland cement of rather narrow composition and well recognized properties.

Portland Cements:

No revisions in the Society's Standard Specifications for Portland Cement (C 9 – 30) are being proposed. Several items have been given considerable study, but no satisfactory conclusions have developed. The requirements for soundness and compressive strength continue to be the ones receiving most attention. In the case of the former a quantitative test is desired and in the latter the committee has not been able to secure sufficient convincing data to warrant a selection of the kind of test specimen or the value for the strength.

Low-Heat-of-Hydration Cements:

Nothing is offered regarding cements having a low heat of hydration. The interest in cements of this type seems to have been almost completely superseded by a desire for a cement having heat of hydration characteristics somewhat lower than those of the high lime standard portland cements, but not as low as those of cements of the Boulder Dam type. The committee has been inclined to await further crystallization of ideas regarding cements less energetic in their reaction with water at early ages than most of the standard portland cements.

Fineness of Cements:

The committee is cognizant of the fact that the interest in and the use of devices to determine fineness and grain size by suspension methods are rapidly increasing and that they are replacing the use of sieving devices. But, again, until cement testers have become more familiar with the use of such devices in daily routine work it has seemed desirable to stand by, but at the same time keep informed as to the reactions being developed by users towards them. Hence, it is recommended that the Tentative Method of Test for Fineness of Portland Cement by Means of the Turbidimeter (C 115 - 34 T) be continued as tentative.

Plastic Mortars:

The Working Committee on Plastic Mortar Tests for Portland Cement (O. L. Moore, chairman) has continued in several laboratories its investigations of problems inherent in a standard compression test. These studies, aimed at possible improvement in uniformity of test results, particularly between laboratories, include (*a*) requirements for cube molds, (*b*) molding of test specimens, (*c*) methods of measuring consistency of mortar, (*d*) water retention and air-voids of mortar and (*e*) grading of sands, including Ottawa sand and an aggregate grading up to $\frac{3}{8}$ in. in size.

The investigations on molding of test specimens and on the effect of planeness of mold faces are yielding positive results and it appears probable that suitable revisions of the Tentative Method of Test for Compressive Strength of Portland-Cement Mortars (C 109 - 34 T) soon may be recommended with reasonable assurance that some improvement in uniformity of test results will be achieved. The investigations of the other problems mentioned have yielded mostly negative results, as for example, the work on standardization of the modified Vicat penetration method for determining consistency of plastic mortar. Although a considerable amount of data has been accumulated, the lack of concordance of test results between laboratories to date is too great to offer any improvement in the Tentative Method C 109 - 34 T. However, the work of the subcommittee has been sufficiently comprehensive to indicate the more promising avenues for further study, and satisfactory progress is anticipated.

It is recommended that the Tentative Method of Test for Compressive Strength of Portland-Cement Mortars (C 109 - 34 T) remain as tentative for another year.

Time of Setting:

The Subcommittee on Time of Setting (R. N. Young, chairman) has started an investigation of a method for determining the time of setting using the so-called plastic-mortar mixture. Very early in its preliminary work it was convinced that the consistency of the mortars should be fixed rather than the percentage of water or the water-cement ratio. Some work had been done by the Working Committee on Plastic Mortar Tests for Portland Cement, using a penetration test. This appeared to hold promise and the subcommittee has included a penetration test for consistency in a series of tests being carried on at the present time. Judging from the data which have been reported, the penetration-consistency test is well worth further attention.

The setting time test upon which study has been concentrated is similar to that now employed upon the neat cement using the Vicat apparatus. Of course the Vicat apparatus required some modification as well as the test specimen. Further preliminary work dealt with the development of these modifications and of the technique involved.

Data are now being submitted to the subcommittee by eight cooperating laboratories based on the following outline of tests:

1. Determination of Normal Consistency—A.S.T.M. Standard Method.
2. Determination of Time of Setting—Gillmore Needles.
3. Determination of Time of Setting—Vicat Apparatus.
4. Determination of Normal Consistency of Plastic Mortar—Proposed Method.
5. Penetration-Time Relation—Proposed Method.

Chemical Analysis:

After giving much thought to the matter of ferrous iron, the Working Committee on Methods of Chemical Analysis (W. C. Hanna, chairman) has reached the conclusion that it may not be practical to include a method for ferrous iron in the methods of chemical analysis of portland cement for some time. It was very difficult to find a simple but satisfactory method for the determination of ferrous iron in the presence of various reducing and oxidizing substances such as organic matter, metallic iron, ferric iron, sulfides, and higher oxides of manganese. Mr. G. E. F. Lundell of the National Bureau of Standards has been studying methods for determining ferrous iron as well as other constituents. He is continuing some preliminary experiments.

A method for the determination of manganese and one for the determination of phosphorus which may eventually prove satisfactory for adoption were submitted by Mr. T. A. Hicks, General Chemist of the Universal Atlas Cement Co., a member of the Working Committee. They were modified to some extent in accordance with suggestions made by Mr. Lundell. However, it is not considered advisable to recommend these methods to the Society before submitting them to a cooperative investigation. Accordingly, such an investigation is being inaugurated. Three samples of cement have been obtained which will be analyzed for manganese and phosphorus. One of the samples is high in manganese and another is high in phosphorus. A number of laboratories are being invited to cooperate and make these determinations. The subcommittee will be pleased to send samples to any who may wish to try the proposed methods which are being published as information in an Appendix to this report. Comments respecting these procedures will be highly appreciated.

It has been interesting to receive the reactions of the cement industry and other groups of workers to the Tentative Method of Chemical Analysis of Portland Cement (C 114 – 35 T). Some of the comments refer to wording or minor details such as the prevention of the CO_2 contamination of ammonia used for the precipitation of aluminum and ferric hydroxides. The other comments concern essential parts of the procedure. These and doubtless other matters which will develop will be given proper consideration before the Tentative Method is proposed for adoption as standard. At this time the committee is not proposing any change in the status of Tentative Method C 114 – 35 T.

Volume Change and Soundness:

The Subcommittee on Volume Change and Soundness of Portland Cement (H. F. Gonnerman, chairman) has been very active. The extent of its work to date is briefed in its report appended hereto. This it is believed will be of much interest to all studying this important question. But as the subcommittee states, much further work is needed before there is attained an accelerated test which will indicate whether a cement will expand excessively in concrete.

Definition of Portland Cements:

As a result of an action taken by the committee a year ago, a special subcommittee composed of six members, with the chairman of Committee C-1 as chairman, was formed to take under consideration the present definition of portland cement as contained in the Society's Standard Specifications for Portland Cement (C 9 – 30). Bearing in mind the present trend of using or advocating the use of other additions subsequent to calcination than water and calcined or uncalcined gypsum, the subcommittee was instructed to make such revisions as it thought advisable. As a result of much interchange of ideas, a report was made by this special subcommittee at the March meeting of the committee. This report was concurred in by five members of the subcommittee and the chairman, but a minority report was included from one of the members. The majority report recommended the adoption of a new definition which would have permitted the use of not more than 1 per cent of additions other than water or any form of calcium sulfate, or both, provided the nature and amount of the other additions was marked on each package. Committee C-1 failed to adopt the recommendation by a record vote which showed 11 affirmative, $16\frac{1}{2}$ negative, and $7\frac{1}{2}$ recorded as not voting. The subcommittee was then instructed to continue its efforts in developing a more suitable definition.

Cement Reference Laboratory:

A report of the Subcommittee on the Cement Reference Laboratory (G. E. Warren, chairman) is appended hereto. This report shows the interest in and value of the work being sponsored for the Society by Committee C-1 on Cement. The work has not only been of tremendous value to the cement industry but has attracted the attention of other industries whose commodities are subjected to testing before acceptance. As a result, other groups are seeking means of establishing such laboratories or systems of inspection to act in a similar capacity to laboratories testing and inspecting the commodities in which they are interested.

RECOMMENDATIONS AFFECTING STANDARDS

The recommendations appearing in this report have been submitted to letter ballot of the committee, which consists of 71 members; 61 members returned their ballots, the results being as follows:

Items	Affirmative	Negative	Ballots Marked "Not Voting"
I. REVISION OF TENTATIVE STANDARD			
Specifications for High-Early-Strength Portland Cement (C 74 - 30 T)[a]	$57\frac{2}{3}$	6	2
II. ADOPTION OF TENTATIVE STANDARD AS STANDARD			
Specifications for High-Early-Strength Portland Cement (C 74 - 30 T), as revised[b]	$54\frac{2}{3}$	10	1

[a] The classified vote on the adoption of the revisions in the Tentative Specifications C 74 - 30 T was as follows: Affirmative: 25 producers, $20\frac{2}{3}$ consumers, 12 general interests; negative: 2 producers, 1 consumer, 3 general interests.

[b] The classified vote on the adoption as standard of the revised Specifications C 74 was as follows: Affirmative: 22 producers, $20\frac{2}{3}$ consumers, 12 general interests; negative: 6 producers, 1 consumer, 3 general interests.

The election of officers for the ensuing term of two years resulted in the re-election of the present chairman and vice-chairmen and the election of Mr. L. W. Walter as secretary.

This report has been submitted to letter ballot of the committee which consists of 71 members; 60 members returned their ballots, all of whom have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

P. H. BATES,
Chairman.

G. A. SAEGER,
Secretary.

REPORT OF WORKING COMMITTEE ON VOLUME CHANGE AND SOUNDNESS OF PORTLAND CEMENT

The Working Committee on Volume Change and Soundness of Portland Cement[1] has for its current objective the study of accelerated soundness tests with a view to the possible development of a more dependable and quantitative test than the present standard 5-hr. exposure of neat cement pats in steam over boiling water. The need for a reliable quantitative measure of the soundness of a cement has long been recognized. The first to report work on this subject was probably Mr. L. Erdmenger, in Germany. Later, others, notably, Messrs. A. H. White, H. J. Force, R. J. Wig and H. A. Davis, studied the problem but no test method meeting with general acceptance was developed as a result of their studies.

A Bibliography on Soundness of Cement, arranged chronologically from 1881 to October, 1935, is appended hereto.

The Working Committee has taken up anew some of the ideas expressed by those who pioneered this field in the belief that if advantage be taken of recently developed methods and the more complete knowledge of the constitution and properties of cement, a suitable accelerated soundness test could be evolved.

Scope of Current Tests.—A start has been made on the testing of seven different groups of cement by subjecting them in the form of neat cement bars to one or more of the following storage conditions or steaming treatments upon removal from molds at 1 day and measuring the resulting expansion or contraction:

1. Stored in air in a room the temperature of which was 80 F. ± 5 F. (27 C. ± 3 C.) and the relative humidity 30 to 40 per cent.
2. Stored in water at a temperature of 70 to 75 F. (21 to 24 C.).
3. Over boiling water at 212 F. for 5 hr.
4. Over boiling water at 212 F. for 24 hr.
5. Over boiling water at 212 F. (100 C.) for 5 hr., in water at 70 F. (21 C.) for 43 hr., and then over boiling water for an additional 19 hr.
6. In autoclave for 24 hr.
7. In autoclave for 48 hr.
8. In autoclave for 72 hr.

Each autoclave period included a 5-hr. heating period to 350 F. (175 C.), 14, 38 or 62 hr. in saturated steam at 350 F. (175 C.), and a 5-hr. cooling period to 212 F. (100 C.).

9. Three cycles of 24 hr. in autoclave and 24 hr. in water at 70 F. (21 C.). Each period in autoclave same as in item 6, above.

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[1] A previous report of the Working Committee was presented in 1934, see *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, p. 356 (1934).

The groups of cement now under investigation include the following:

1. Pure compounds of portland cement including C_3S, C_2S, C_3A, C_4AF and mixtures of these compounds with and without MgO.
2. Eighteen laboratory-prepared cements, MgO and C_2S variable.
3. Ten laboratory-prepared cements, MgO variable.
4. Twelve laboratory-prepared cements, free lime, C_3S, and MgO variable.
5. Twenty commercial portland cements.
6. Thirty-four high-early-strength cements distributed by the Sponsoring Committee on High-Early-Strength Cement.
7. Miscellaneous commercial cements including portland cements, special cements, natural cements, etc.

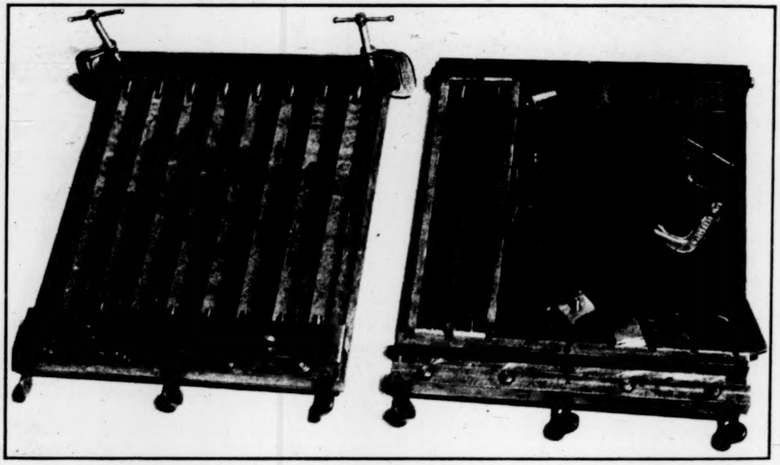

FIG. 1.—View Showing Details of Construction and Assembly of Gang Molds Used in Making 1 by 1 by 11¼-in. Bars for Linear Expansion and Contraction Measurements.

Reference points are screws of stainless steel cast in ends of bars to give an effective gage length of 10 in. between the embedded ends of the screws.

The work done to date on these different groups of cements has been carried out by the Portland Cement Association Fellowship at the National Bureau of Standards, Washington, D. C., and at the Research Laboratory of the Portland Cement Association, Chicago, Ill. If this preliminary work yields information of significance it is planned to inaugurate a coöperative series in several laboratories for the purpose of trying out test procedures that appear promising. This progress report concerns only the results of tests to date on the high-early-strength cements in group 6 above.

TESTS OF 34 HIGH-EARLY-STRENGTH CEMENTS

Each of the 34 cements under investigation by the Sponsoring Committee on High-Early-Strength Cements, of Committee C-1, was tested for expansion or contraction in neat cement bars which were subjected upon removal from molds to conditions 1, 2, 5, 6, 7, 8 and 9, listed in the preceding section on Scope of Current Tests.

Apparatus and Test Specimens.—The specimen molds, the instrument for measuring length changes, and the autoclave apparatus used in the tests are shown in Figs. 1 to 3.

The test specimens were 1-in. square bars, 11¼ in. in length. They were provided with ¼-in. stainless steel reference plugs at each end which projected $\frac{3}{16}$ in. beyond the end of the bar. The distance between the embedded ends of the plugs was exactly 10 in. which was considered as the effective length of the specimen in calculating unit changes in length.

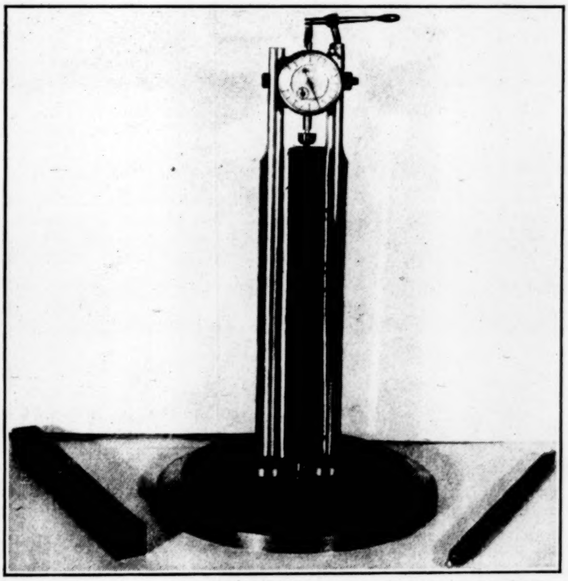

FIG. 2.—Instrument with Dial Graduated to 0.0001 in. Used to Measure the Expansion and Contraction of Neat Cement Bars over an Effective Gage Length of 10 in.

Four specimens of a kind were usually made at one time from neat cement paste mixed to A.S.T.M. normal consistency. The method of mixing used conformed to the A.S.T.M. standard procedure as described in the Standard Methods of Sampling and Testing Portland Cement (C 77 – 32), except that the total mixing time was increased to 3½ min. because of the large batches, and a small ⅞-in. square-ended tamper was used to aid in placing the paste in the molds. The tamper was especially useful in placing those cements which stiffened quickly.

Method of Testing.—Upon removal from the molds (20 to 24 hr. after casting) the specimens were placed in water at 70 F. (21 C.) for 1 hr., then surface-dried and measured for initial length and weight. Subsequent measurements were made at frequent intervals during the first few days, but as the changes in length and weight became smaller the period between measurements was extended. Specimens stored in air were measured at the temperature of the storage room which varied from 75 to 85 F. (24 to 29 C.). Specimens stored in water at 70 F. (21 C.) were measured at 70 F. (21 C.). Length measurements for each cement are now available up to the age of 3 months.

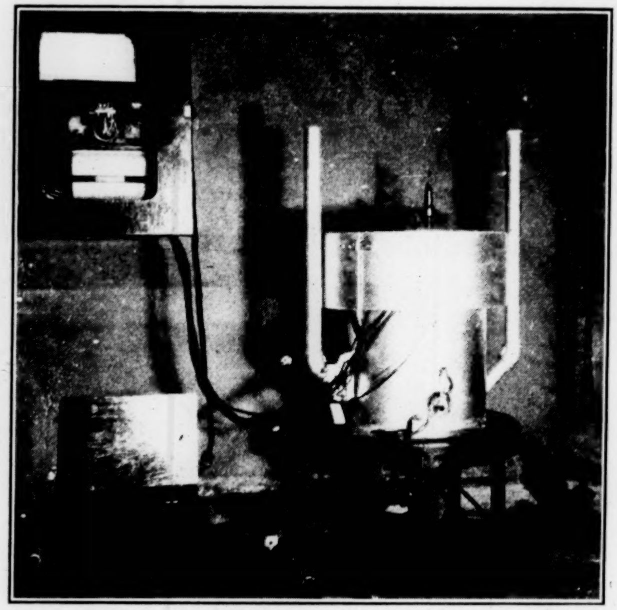

FIG. 3.—View Showing Insulated, Gas-Fired Autoclave, High-Pressure Hydraulic Feed Pump, and Automatic Temperature Recorder.

Specimens steamed at 212 F. (100 C.) and autoclaved at 350 F. (175 C.) were, at the end of the steaming periods, placed in boiling water and the container placed in the moist room until cooled to 70 F. (21 C.). All measurements for length and weight were made at a temperature of 70 F. (21 C.).

DISCUSSION OF TESTS

Data of Tests.—Expansions or contractions after the various treatments are reported in Table I. In Table I the cements are arranged in ascending order of the 72-hr. autoclave expansions (group 1). Each value in the table is the result of a single test. Other data relating to the cements are given in Table II. Data from Table I are plotted in Fig. 4 to show the influence of the duration of the exposure in the autoclave on the measured expansions.

Comparison of Length Changes.—Figure 5 shows the measured expansions or contractions of each cement when subjected to the various conditions of test, the cements being arranged in the order of the magnitude of their expansions when steamed at 212 F. (100 C.) for 24 hr. In Fig. 6 the expansions in water at the 90-day period have been plotted against the

TABLE I.—LENGTH CHANGES OF 34 HIGH-EARLY-STRENGTH CEMENTS.

Cements arranged in ascending order of 72-hr. autoclave expansions (Group 1). All cements were sound when tested for soundness over boiling water in accordance with the A.S.T.M. Standard Methods of Sampling and Testing Portland Cement (C 77 - 32).

Each value represents a test on one 1 by 1 by 10-in. bar of neat cement mixed to normal consistency. Bars cured 20 to 24 hr. in mold in moist closet at 70 to 75 F. (21 to 24 C.) and 100 per cent relative humidity. Upon removal from molds bars were placed in water at 70 F. (21 C.) for 1 hr., surface-dried and measured for length and weight, and then treated as indicated below:

Specimens in air were stored in a room the temperature of which was 80 F. ± 5 F. (27 C. ± 3 C.) and the relative humidity 30 to 40 per cent.

Specimens in water were stored in a tank in a moist room at a temperature of 70 to 75 F. (21 to 24 C.).

Specimens steamed at 212 F. (100 C.) were placed over boiling water for 5 hr., then stored in water for 43 hr. and then again placed over boiling water for 19 hr. (24 hr. total steaming at 212 F. (100 C.)).

Specimens steamed at 350 F. (175 C.) were in two groups as follows:

Group (1) { In autoclave 24 hr. / In autoclave 48 hr. / In autoclave 72 hr. } One specimen from each cement tested for each autoclave period which included a 5-hr. heating period to 350 F. (175 C.), a 14, 38 or 62-hr. period in saturated steam at 350 F. (175 C.), and a 5-hr. cooling period to 212 F. (100 C.).

Group (2) { Specimens given 3 cycles in autoclave at 350 F. (175 C.). Each cycle included 24 hr. in autoclave (5-hr. heating period to 350 F. (175 C.), 14 hr. at 350 F. (175 C.) and 5-hr. cooling to 212 F. (100 C.) followed by 24 hr. in water

All specimens steamed at 212 F. (100 C.) or autoclaved at 350 F. (175 C.) were cooled from 212 F. (100 C.) to 70 F. (21 C.). in water. After 24 hr. in water specimens were surface-dried and measured for length and weight.

Cement No.	Expansion for Storage Condition Indicated, per cent (Minus sign indicates contraction)												
	In Air			In Water			In Steam at 212 F. (100 C.)		In Autoclave				
									Group 1			Group 2	
	28 days	60 days	90 days	28 days	60 days	90 days	5 hr.	24 hr.	24 hr.	48 hr.	72 hr.	48 hr.	72 hr.
29	−0.265	−0.300	−0.308	0.027	0.038	0.046	−0.008	−0.011	−0.034	−0.025	−0.019	−0.031	−0.030
23	−0.264	−0.295	−0.307	0.024	0.037	0.043	0.009	0.009	−0.009	−0.012	−0.008	−0.007	−0.003
19	−0.256	−0.289	−0.300	0.014	0.029	0.035	0.009	0.007	−0.004	−0.004	0.002	−0.001	0.001
21	−0.250	−0.281	−0.290	0.028	0.041	0.051	−0.001	0.004	−0.004	0.006	0.008	0.000	0.000
30	−0.272	−0.299	−0.308	0.019	0.030	0.039	−0.001	−0.001	−0.008	0.003	0.012	−0.002	0.003
34	−0.230	−0.262	−0.267	0.013	0.025	0.033	−0.003	−0.006	−0.011	0.004	0.016	−0.001	0.007
1	−0.242	−0.270	−0.280	0.028	0.043	0.055	0.015	0.012	0.008	0.009	0.016	0.012	0.016
31	−0.215	−0.248	−0.250	−0.005	0.008	0.012	−0.008	−0.015	−0.018	0.002	0.019	−0.003	0.008
5	−0.224	−0.258	−0.259	0.011	0.022	0.030	0.006	0.004	0.016	0.024	0.042	0.032	0.050
11	−0.268	−0.312	−0.320	0.035	0.051	0.061	0.020	0.022	0.026	0.046	0.057	0.036	0.042
10	−0.259	−0.289	−0.297	0.033	0.050	0.064	0.002	0.014	0.026	0.047	0.057	0.042	0.053
24	−0.322	−0.360	−0.370	0.028	0.045	0.060	0.013	0.020	0.034	0.046	0.058	0.047	0.058
9	−0.255	−0.289	−0.300	0.009	0.020	0.030	0.003	0.002	0.035	0.047	0.062	0.052	0.064
32	−0.289	−0.330	−0.337	0.039	0.057	0.065	0.021	0.030	0.047	0.065	0.083	0.064	0.076
14	−0.324	−0.362	−0.378	0.035	0.056	0.068	0.027	0.040	0.048	0.075	0.098	0.065	0.079
6	−0.230	−0.264	−0.273	0.029	0.045	0.060	0.016	0.029	0.075	0.085	0.104	0.107	0.135
4	−0.265	−0.293	−0.307	0.034	0.050	0.060	0.016	0.030	0.069	0.081	0.111	0.094	0.115
15	−0.279	−0.311	−0.321	0.051	0.068	0.081	0.019	0.036	0.057	0.090	0.112	0.080	0.100
16	−0.225	−0.251	−0.261	0.030	0.049	0.060	0.013	0.027	0.062	0.092	0.120	0.092	0.117
7	−0.268	−0.297	−0.307	0.031	0.053	0.068	0.001	0.027	0.074	0.098	0.124	0.096	0.114
28	−0.258	−0.300	−0.308	0.041	0.063	0.072	0.034	0.052	0.072	0.100	0.128	0.092	0.107
18	−0.211	−0.248	−0.260	0.022	0.040	0.051	0.019	0.038	0.063	0.105	0.141	0.093	0.118
3	−0.255	−0.282	−0.290	0.024	0.042	0.059	0.014	0.028	0.061	0.117	0.144	0.102	0.137
22	−0.247	−0.277	−0.291	0.032	0.048	0.059	0.015	0.025	0.061	0.100	0.146	0.097	0.131
17	−0.266	−0.297	−0.308	0.050	0.074	0.083	0.026	0.042	0.094	0.116	0.146	0.122	0.145
12	−0.257	−0.300	−0.311	0.020	0.031	0.041	0.028	0.032	0.071	0.106	0.170	0.100	0.130
33	−0.224	−0.258	−0.263	0.028	0.042	0.050	0.000	−0.006	0.061	0.126	0.194	0.104	0.148
13	−0.241	−0.268	−0.278	0.014	0.028	0.037	0.013	0.008	0.076	0.105	.....	0.116	0.155
25	−0.260	−0.281	−0.290	0.070	0.089	0.101	0.071	0.089	0.132	0.161	0.210	0.174	0.210
27	−0.262	−0.298	−0.301	0.020	0.030	0.040	0.006	0.010	0.071	0.141	0.249	0.125	0.180
20	−0.279	−0.320	−0.339	0.052	0.080	0.093	0.036	0.064	0.141	0.234	0.351	0.217	0.320
26	−0.238	−0.279	−0.280	0.027	0.050	0.060	0.027	0.052	0.149	0.297	0.550	0.274	0.473
2	−0.284	−0.300	−0.306	0.076	0.105	0.130	0.089	0.126	0.583	0.930	1.056	1.140	1.290
8	−0.139	−0.150	−0.150	0.125	0.170	0.200	0.157	0.244	0.635	0.890	1.210	1.030	1.420

Table II.—Chemical Analyses and Miscellaneous Data of 34 High-Early-Strength Cements.

The 34 cements represented in these tests were supplied for the cooperative tests of the Sponsoring Committee on High-Early-Strength Cements, of Committee C-1. Two bags of each cement were furnished in cloth or paper sacks together with a 25-lb. sample for special tests, the latter being shipped in most cases in sealed metal containers.

The chemical analyses reported in this table were made on the cement shipped in cloth or paper bags since this was used in the strength and miscellaneous tests reported to the Sponsoring Committee.

Free lime determinations were made on both the cement shipped in cloth or paper bags (column A) and that shipped in the sealed metal containers (column B). The length change specimens were made from the cement shipped in the metal containers.

In the chemical analyses each value is the average of two to four determinations.

Analyses for major constituents were made by the usual Portland Cement Association methods, which conform closely to A.S.T.M. methods.

Minor constituents were determined by the following methods:

Na_2O and K_2O by J. Lawrence Smith Method.

TiO_2, P_2O_5 and MnO according to Meade's "Portland Cement," Chapter X.

FeO by method furnished by R. H. Bogue.

Free CaO by method of Bogue and Lerch. See footnote in text under paragraph on "influence of cement constituents on length changes."

In calculating the potential C_3S and C_2S compounds allowance was made for free CaO (column A) and insoluble residue.

Compressive strengths at 3 months are based on tests of 6 by 12-in. concrete cylinders of 1:2.72:4.32 mix by weight and 0.80 water-cement-ratio by volume.

Water for normal consistency was determined in accordance with the A.S.T.M. Standard Methods of Sampling and Testing Portland Cement (C 77 - 32).

Surface areas were determined with the Wagner turbidimeter in accordance with the A.S.T.M. Tentative Method of Test for Fineness of Portland Cement by Means of the Turbidimeter (C 115 - 34 T).

Cement No.	Major Constituents, per cent						Minor Constituents, per cent										Potential Compound Composition, per cent						Water for Normal Consistency, per cent	Surface Area, sq. cm. per gram	Compressive Strength of Concrete at 3 months, lb. per sq. in.	Length Change, per cent (Minus sign indicates contraction)		
	SiO_2	Fe_2O_3	Al_2O_3	Total CaO	MgO	SO_3	Na_2O	K_2O	TiO_2	P_2O_5	FeO	MnO	Free CaO A	Free CaO B	Insoluble Residue	Loss on Ignition	C_3S	C_2S	C_3A	C_4AF	MgO	$CaSO_4$				At 90 days in Water at 70 F. (21 C.)	At 24 hr. in Steam at 212 F. (100 C.)	At 72 hr. in Autoclave at 350 F. (175 C.)
Cements Showing Expansions of 0.019 per cent or Less During 72 hr. in Autoclave at 350 F. (175 C.)																												
29	21.84	2.06	4.50	66.23	1.53	2.08	0.22	0.05	0.25	0.07	0.04	0.18	0.19	0.61	0.67	1.24	69	9	8	6	1.5	3.5	23.5	2720	6800	0.046	−0.011	−0.019
23	19.59	5.07	5.39	63.54	1.24	2.23	0.15	0.55	0.31	0.18	0.33	0.21	1.83	1.76	0.22	2.02	54	15	6	15	1.2	3.8	27.0	2510	6570	0.043	0.009	−0.008
19	20.10	2.99	6.25	63.34	1.47	2.47	0.26	0.41	0.33	0.11	0.11	0.18	1.03	1.09	0.14	2.28	49	21	12	9	1.5	4.2	26.0	2685	6870	0.035	0.007	0.002
21	21.48	1.95	4.21	65.95	2.13	2.15	0.19	0.15	0.22	0.08	0.17	0.06	1.06	0.97	0.21	1.64	65	12	8	6	2.1	3.7	25.0	2715	7020	0.051	0.004	0.008
30	20.36	3.00	5.61	64.67	1.73	2.18	0.21	0.29	0.26	0.05	0.06	0.09	0.72	0.58	0.21	1.53	59	13	10	9	1.7	3.7	25.0	2265	5550	0.039	−0.001	0.012
34	20.81	2.17	6.54	65.35	1.21	2.34	0.16	0.24	0.25	0.15	0.38	0.08	0.42	0.62	0.28	1.28	55	18	14	7	1.2	4.0	27.0	2805	....	0.033	−0.006	0.016
1	20.67	3.36	4.50	66.06	1.19	2.23	0.33	0.52	0.26	0.15	0.09	0.09	0.92	0.73	0.06	1.11	67	8	6	10	1.2	3.8	24.5	2300	5640	0.055	0.012	0.016
31	18.65	3.61	6.96	65.34	0.97	2.39	0.28	0.38	0.40	0.22	0.08	0.29	0.35	0.58	0.10	1.15	65	4	12	11	1.0	4.1	24.5	2400	7140	0.012	−0.015	0.019
Average	20.44	3.03	5.50	65.06	1.43	2.26	0.26	0.32	0.29	0.13	0.16	0.15	0.82	0.87	0.24	1.53	60	13	10	9	1.4	3.9	25.3	2550	6713	0.039	0.000	0.006
Cements Showing Expansions of 0.020 to 0.099 per cent During 72 hr. in Autoclave at 350 F. (175 C.)																												
5	19.51	2.05	6.02	67.15	0.99	2.16	0.23	0.26	0.35	0.09	0.14	0.05	1.67	1.62	0.09	1.43	69	3	12	6	1.0	3.7	25.0	2340	6400	0.030	0.004	0.042
11	19.26	3.61	6.09	63.53	2.22	2.25	0.31	0.70	0.35	0.09	0.04	0.07	0.80	1.53	0.23	1.85	58	11	10	11	2.2	3.8	27.0	2495	6160	0.061	0.022	0.057
10	19.56	2.19	5.16	66.12	2.08	2.25	0.27	0.64	0.23	0.27	0.04	0.08	0.95	1.48	0.13	1.16	73	0	10	7	2.1	3.8	24.5	1950	7120	0.064	0.014	0.057
24	20.12	2.80	5.32	65.29	2.20	1.82	0.47	0.25	0.32	0.10	0.05	0.13	1.18	0.63	0.14	1.56	64	9	9	9	2.2	3.1	24.0	2465	5250	0.060	0.020	0.058
9	19.49	4.23	6.01	63.51	1.60	2.60	0.31	0.56	0.34	0.16	0.09	0.08	1.23	0.94	0.12	1.77	52	16	9	13	1.6	4.4	26.5	2560	6740	0.030	0.002	0.062
32	19.98	3.94	5.46	62.88	1.76	2.69	1.17	0.07	0.31	0.12	0.16	0.08	1.58	1.93	1.09	1.82	56	12	8	12	1.8	4.6	24.0	2530	5550	0.065	0.030	0.083
14	19.93	2.82	6.37	62.67	2.77	2.54	0.45	0.63	0.30	0.28	0.26	0.10	0.86	0.69	0.24	1.80	48	20	12	9	2.8	4.3	26.0	2580	7400	0.068	0.040	0.098
Average	19.69	3.09	5.77	64.45	1.95	2.33	0.46	0.44	0.31	0.16	0.11	0.08	1.18	1.26	0.29	1.63	60	10	10	10	2.0	4.0	25.3	2417	6374	0.054	0.019	0.065

Cements Showing Expansions of 0.100 to 0.199 per cent During 72 hr. in Autoclave at 350 F. (175 C.)

6	21.63	3.02	4.06	63.20	3.96	2.32	0.27	0.41	0.22	0.12	0.02	0.11	0.40	1.02	0.21	1.11	55	20	6	9	4.0	3.9	25.0	2100	6130	0.060	0.029	0.104
4	20.42	2.54	6.57	63.61	2.75	2.42	0.23	0.45	0.45	0.07	0.07	0.08	0.53	1.10	0.21	1.13	48	21	13	8	2.8	4.1	29.0	2740	7130	0.060	0.030	0.111
15	20.69	1.98	5.19	64.46	3.42	2.33	0.27	0.33	0.24	0.11	0.04	0.05	1.32	0.90	0.12	1.33	56	17	10	6	3.4	4.0	27.5	2775	6740	0.081	0.036	0.112
16	19.43	3.29	5.07	65.44	2.86	2.00	0.24	0.12	0.32	0.09	0.05	0.18	2.66	2.01	0.06	1.43	64	7	8	10	2.9	3.4	23.5	2415	5810	0.060	0.027	0.120
7	19.54	2.79	5.33	64.75	2.88	2.42	0.18	0.43	0.34	0.08	0.18	0.05	1.08	1.37	0.10	1.35	65	7	9	8	2.9	4.1	25.5	2620	7170	0.068	0.027	0.124
28	20.00	3.25	6.30	63.39	2.29	2.38	0.43	0.64	0.35	0.17	0.07	0.25	1.60	1.38	0.14	1.34	47	22	11	10	2.3	4.0	24.5	2635	7390	0.072	0.052	0.128
18	19.78	2.86	5.33	64.79	3.43	2.39	0.27	0.32	0.31	0.12	0.06	0.12	0.44	0.29	0.09	0.80	66	7	9	9	3.4	4.1	23.5	2480	6650	0.051	0.038	0.141
3	19.97	2.01	5.61	63.19	3.97	2 32	0.30	0.31	0.24	0.25	0.05	0.12	0.92	1.50	0.32	2.37	57	13	11	6	4.0	3.9	24.5	2775	....	0.059	0.028	0.144
22	20.53	2.12	5.97	64.50	2.58	2.32	0.20	0.40	0.33	0.15	0.05	0.05	0.85	0.78	0.16	1.33	55	17	12	6	2.6	3.9	25.0	2415	6870	0.059	0.025	0.146
17	19.05	3.45	5 99	64.02	3.00	2.16	0.47	0.41	0.35	0.11	0.02	0.14	2.44	2.12	0.08	1.61	55	13	10	10	3.0	3.7	28.5	2940	6720	0.083	0.042	0.146
12	20.27	2.75	6.31	63.82	1.79	2.33	0.20	0.92	0.33	0.06	0.05	0.05	1.06	0.95	0.21	1.45	50	20	12	8	1.8	4.0	23.5	2410	6160	0.041	0.032	0.170
33	18.84	3.00	6.56	65.57	0.77	2.87	0.15	0.31	0.43	0.19	0.04	0.21	1.99	2.65	0.16	1.87	60	8	12	9	0.8	4.9	25.5	2695	6720	0.050	−0.006	0.194
13	19.64	3.17	6.72	63.81	1.12	2.54	0.21	0.69	0.42	0.07	0.19	0.03	1.93	1.50	0.14	2.12	47	21	12	10	1.1	4.3	24.5	2540	6380	0.037	0.008	.....
Average	20.00	2.79	5.77	64.20	2.68	2.37	0.26	0.44	0.33	0.12	0.07	0.11	1.33	1.35	0.15	1.48	57	15	10	8	2.7	4.0	25.4	2850	6656	0.060	0.028	0.137

Cements Showing Expansions of 0.200 to 0.299 per cent During 72 hr. in Autoclave at 350 F. (175 C.)

25	20.26	2.38	5.38	64.92	2.06	2.30	0.44	0.45	0.30	0.18	0.05	0.08	3.16	3.20	0.13	1.66	52	18	10	7	2.1	3.9	29.5	2600	6610	0.101	0.089	0.210
27	19.59	2.92	6.34	65.98	0.82	2.12	0.15	0.67	0.33	0.10	0.12	0.08	1.80	1.83	0.13	1.36	61	10	12	9	0.8	3.6	26.0	2295	6830	0.040	0.010	0.249
Average	19.92	2.65	5.86	65.45	1.44	2.21	0.30	0.56	0.32	0.14	0.08	0.08	2.48	2.52	0.13	1.51	56	14	11	8	1.4	3.8	27.6	2448	6720	0.070	0.050	0.230

Cements Showing Expansions of 0.300 to 0.399 per cent During 72 hr. in Autoclave at 350 F. (175 C.)

20	19.34	2.38	5.70	64.21	3.17	2.37	0.42	0.77	0.34	0.05	0.03	0.07	2.11	2.23	0.15	1.42	58	11	11	7	3.2	4.0	25.0	2390	6250	0.093	0.064	0.351

Cements Showing Expansions of 0.500 to 0.599 per cent During 72 hr. in Autoclave at 350 F. (175 C.)

26	18.42	2.47	6.68	64.34	3.32	2.55	0.35	0.49	0.31	0.29	0.05	0.09	0.87	1.70	0.10	1.33	63	5	14	8	3.3	4.3	24.5	2355	6480	0.060	0.052	0.550

Cements Showing Expansions of Over 1 per cent During 72 hr. in Autoclave at 350 F. (175 C.)

2	18.72	2.21	6.56	63.62	3.56	2.37	0.37	0.57	0.27	0.25	0.03	0.11	2.11	2.46	0.19	2.09	56	11	14	7	3.6	4 0	27.5	2540	6180	0.130	0.126	1.056
8	17.98	2.80	5.64	64.56	3.72	1.77	0.20	0.60	0.30	0.60	0.24	0.08	6.00	6.48	0.11	2.47	56	9	10	9	3.7	3.0	24.0	3040	6570	0.200	0.244	1.210
Average	18.35	2.50	6.10	64.09	3.64	2.07	0.28	0.58	0.28	0.42	0.14	0.10	4.06	4.47	0.15	2.28	56	10	12	8	3.6	3.5	25.8	2790	6375	0.165	0.185	1.133

expansions shown by bars steamed at 212 F. (100 C.) or 350 F. (175 C.) for different periods.

From Table I and Fig. 5 it will be noted that the magnitude of the expansions during the 24-hr. period in steam at 212 F. (100 C.) are in general low, in no case being greater than 0.25 per cent and in only one case greater than 0.13 per cent. Of the 34 cements tested, 28 cements expanded less than 0.05 per cent, while 5 cements showed a slight contraction. The expansions or contractions during the 5-hr. period in steam at 212 F. (100 C.) paralleled the 24-hr. values but were generally of less magnitude.

The expansions occurring during 90 days storage in water likewise paralleled the values for 24 hr. in steam at 212 F. (100 C.) but were generally of greater magnitude. As may be seen from Fig. 6, a fairly definite relationship appears to exist between the expansions in water at 90 days and those at 5 hr. or 24 hr. in steam at 212 F. (100 C.).

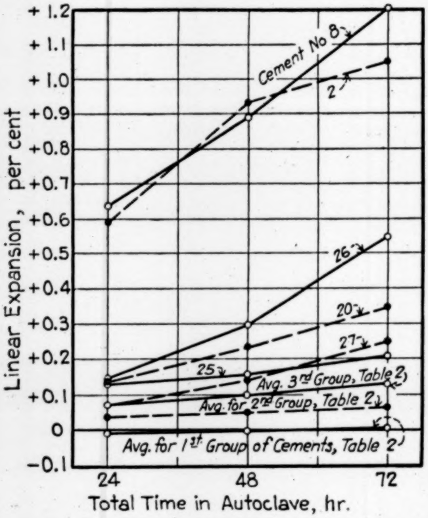

FIG. 4.—Expansion of Neat Cement Bars as Influenced by Duration of Exposure in Autoclave.

Except in a few cases the contractions occurring during 90 days storage in air were not greatly different for the various cements and they appear to bear no relation to the expansions in water or in steam at 212 F. (100 C.). Cement No. 5 which expanded most in the latter storage contracted least in air. This cement contained the highest indicated amount of free lime. The effect of high free lime would be to cause an expansion which would offset part of the shrinkage.

The data obtained from steaming in the autoclave at 350 F. (175 C.) for 24 to 72 hr. are of special interest inasmuch as some of the cements (Nos. 33, 27, 26 and 20) show expansions relatively very much greater than in any of the other tests (see upper diagram of Fig. 5.) These increased expansions are probably due to the accelerated hydration of certain of the cement constituents at the higher temperature. The significance of these results will not appear until the later behavior of the water-stored specimens is known. If it should be found that these high expansions in the autoclave are indicative of excessive expansions in water at the later periods, this test will have considerable significance.

Influence of Cement Constituents on Length Changes.—Some length change measurements on bars made from the pure compounds existing in portland cement and with synthetic mixtures of these compounds, have indicated that among the constituents causing expansion during storage in water or exposure to moist steam are free CaO, MgO and C_3A. Consequently, the data were also studied in the light of the effects of these three constituents on the expansions which developed under the various treatments. Chemical analyses and certain other data relating to the cements are given in Table II. For convenience of study, the cements in this table are arranged in seven groups according to the magnitude of their expansions during 72 hr. in the autoclave at 350 F. (175 C.), as recorded in Table I under the heading Group 1.

The detailed study of the influence of free CaO, MgO and C_3A showed that for the 34 cements tested, the indicated free CaO content[1] had the greatest effect on expansion. When those cements having indicated free lime contents of over 2 per cent were omitted from consideration it appeared that for the remaining cements an increase in the MgO content was, in general, responsible for but relatively slight increase in expansion. The MgO contents of the 34 cements were less than 4 per cent so that it was not possible to study the effects of MgO when present in greater quantities. In the study of the effect of C_3A content it was found that as this constituent increased there was a slight trend toward increased expansion although the relationship was not well defined, probably due to variations in the amounts of the other cement constituents which produce expansion.

In Fig. 7 are shown relationships between the indicated free lime content of the cements and the length changes of neat cement bars steamed at 212 F. (100 C.) or in autoclave at 350 F. (175 C.) for various periods, or stored in water at 70 to 75 F. (21 to 24 C.) for 90 days. Considering the uncertainties in the free lime determinations, the unknown effects on the measured length changes of differences in fineness and of variations in the other constituents causing expansion, and in view of the fact that each plotted value represents a single test it is not surprising that in some of the diagrams of Fig. 7 the plotted points deviate considerably from the

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[1] The term "indicated free CaO content" is used in this discussion and in Figs. 7 and 8 because the values for free lime (CaO) reported in Table II may not represent the amount of free lime actually present in the cements at the time of test. Any free lime that may have been present in the clinkers, may in the ground cements be present either as free lime or, due to exposure to moisture and CO_2, may have been changed entirely or in part to either $Ca(OH)_2$ or $CaCO_3$, or both. In applying the Bogue-Lerch method of analysis for free CaO to the cements as received, the $CaCO_3$ present in the cement is not determined and any $Ca(OH)_2$ present is determined as free CaO. Thus, since each of the cements when received may have been exposed in some degree to both moisture and CO_2, the relation of the free lime values in Table II to the true values at time of test is more or less uncertain.

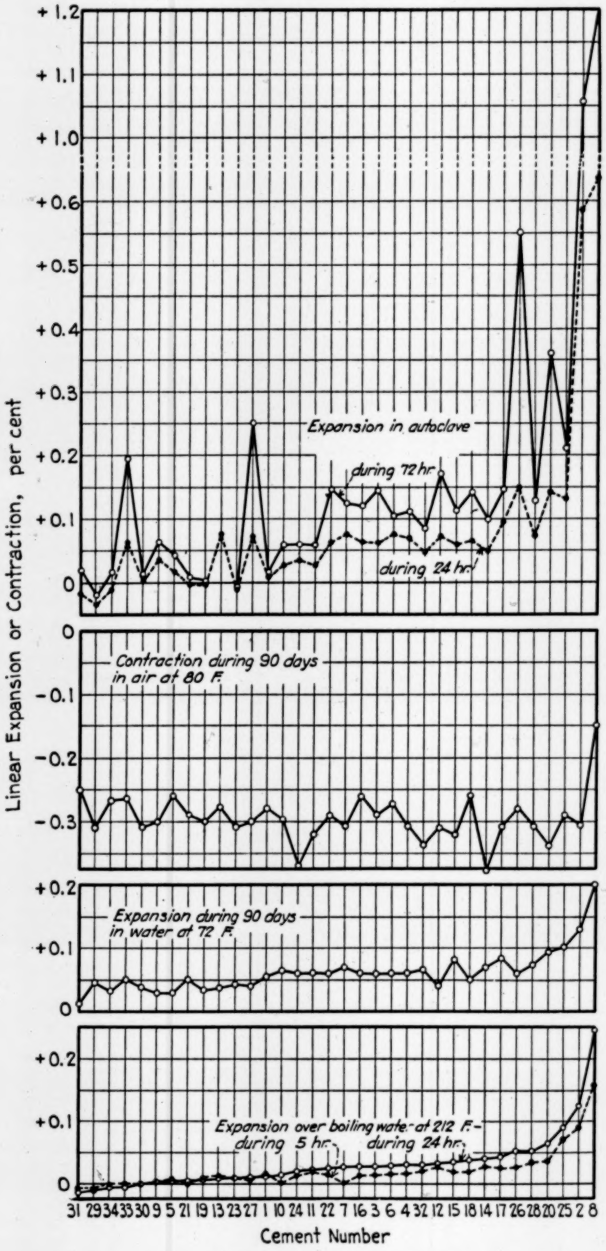

FIG. 5.—Length Changes of 1 by 1 by 10-in. Neat Cement Bars for Various Conditions of Test.

Cements arranged in ascending order of expansions during 24 hr. over boiling water.

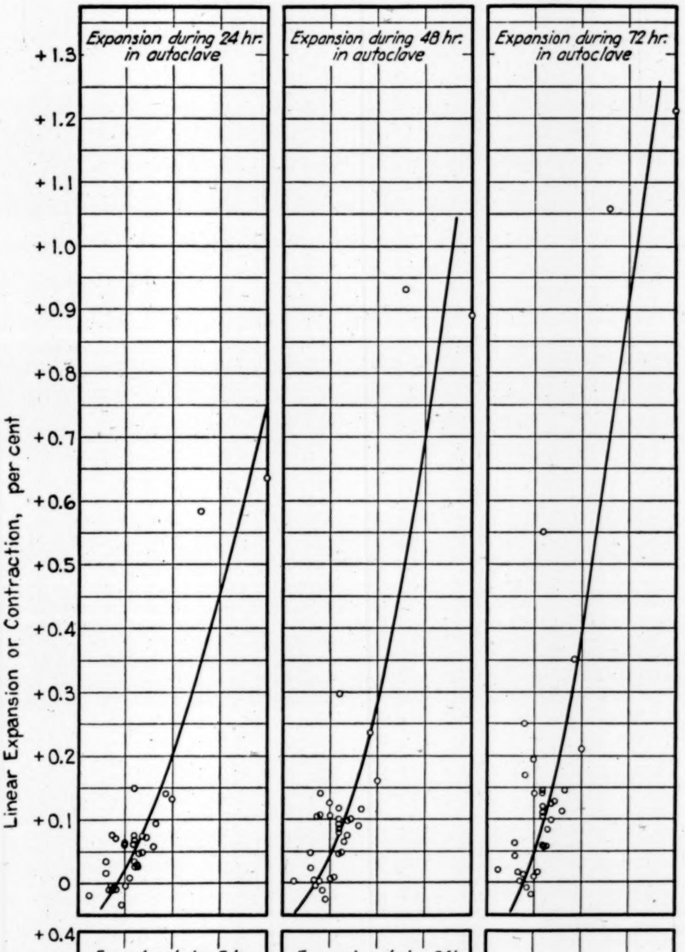

FIG. 6.—Relationship Between Length Changes of 1 by 1 by 10-in. Neat Cement Bars Stored 90 Days in Water and Bars Steamed in Autoclave or Over Boiling Water.

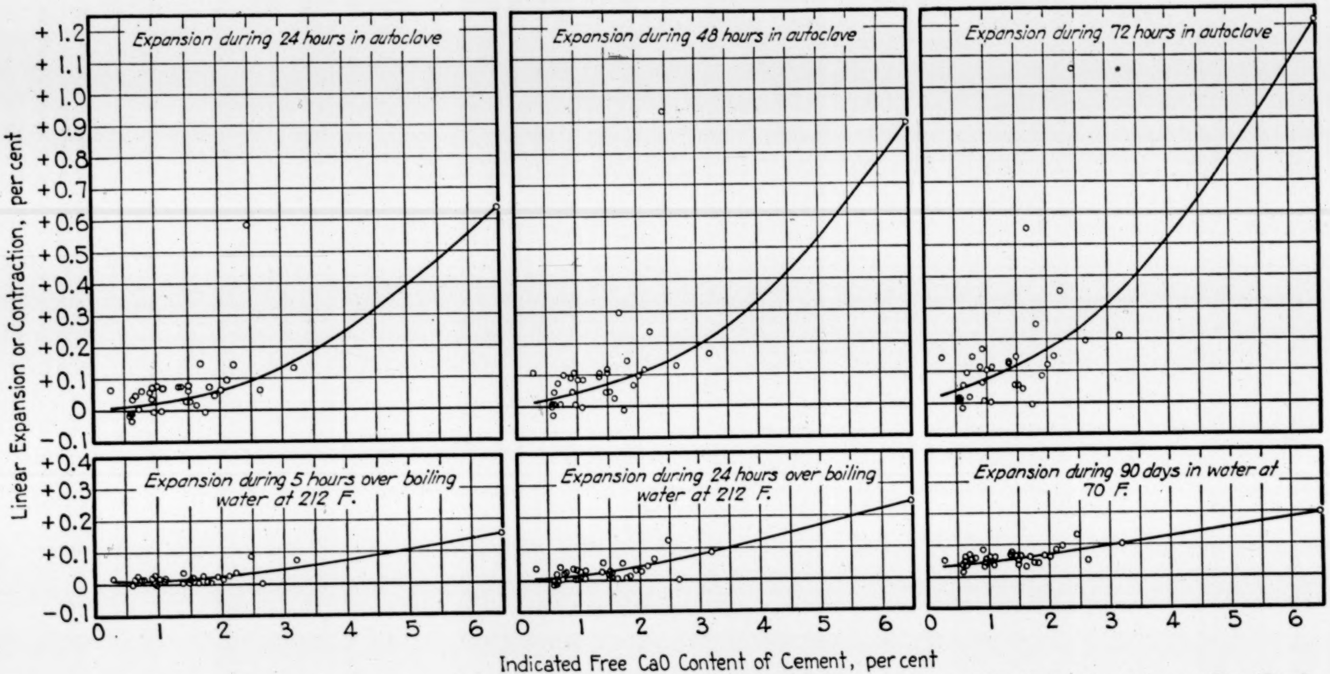

FIG. 7.—Relationship Between Indicated Free Lime Content of Cement and Length Change of 1 by 1 by 10-in. Neat Cement Bars During Various Storage Conditions.

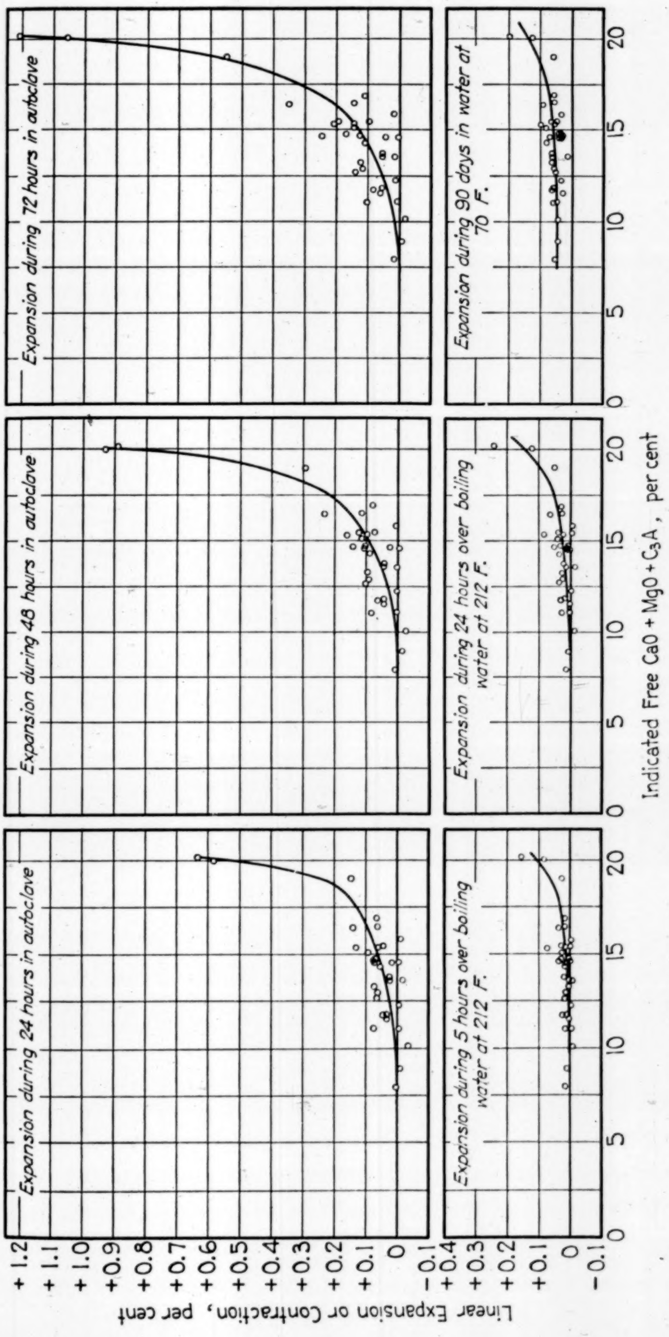

FIG. 8.—Relationship Between Indicated Free Lime plus Magnesia plus Tricalcium Aluminate Content of Cement and Length Change of 1 by 1 by 10-in. Neat Cement Bars During Various Storage Conditions

curves. However, the trend of the curves indicates that as the free lime content increases the expansion increases for all of the test conditions represented.

In Fig. 8 the sum of the percentages of the major cement constituents known to produce expansion (free CaO, MgO and C_3A) have been plotted against the expansions. In general, for all of the six conditions of test represented, the expansions increased as the sum of these constituents increased. There is less scattering of the points in the diagrams of this figure than when the expansions were plotted against percentage of free lime only as in Fig. 7. In plotting Figs. 7 and 8 the free CaO values in column B of Table II were used. When the values in column A of Table II were used, diagrams similar to those shown in Figs. 7 and 8 were obtained but are not included in this report.

Summary of Results.—The principal indications shown by the data available to date may be summarized as follows:

1. Neat cement bars during storage in water for 90 days or during steaming over boiling water at 212 F. (100 C.) for 5 or 24 hr. showed small expansions, usually less than 0.1 per cent, for all of the 34 cements studied.

2. Neat cement bars steamed in autoclave at 350 F. (175 C.) for 24, 48, or 72 hr. showed increased expansion with increase in the duration of the steaming treatment. For 28 of the 34 cements tested, the expansions during 72 hr. in the autoclave were less than 0.20 per cent. Of the remaining 6 cements, one expanded 1.21 per cent, the other 5 gave results between 0.21 and 1.06 per cent.

3. The expansions of neat cement bars during exposure to steam at 212 or 350 F. (100 or 175 C.) were indicative of the expansions of similar bars during 90 days storage in water at 70 F. (21 C.). Steaming at 212 F. (100 C.) showed the best correlation with 90-day water storage at this stage of the tests. With the exception of 4 cements, expansion in the autoclave also gave good correlation. Too much cannot be expected of a few cements, but if these 4 cements later show similarly high expansion in water, this test will have considerable significance.

4. Free CaO appears to have been the principal cause of the expansions which occurred in these tests. Apparently, only relatively slight increases in expansion were attributable to the MgO and C_3A contents over the range of MgO (0.8 to 4.0 per cent) and C_3A (6 to 14 per cent) present in the cements tested.

5. The results secured to date justify continuing the studies in order to explore more completely the possibilities of developing an accelerated test which will definitely disclose whether or not a cement will expand excessively when used in concrete.

Respectfully submitted on behalf of the working committee,

H. F. GONNERMAN,
Chairman.

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Preliminary Report of Committee, of the American Society of Civil Engineers, on Uniform Tests of Cement, *Transactions*, Am. Soc. Civil Engrs., Vol. 13, p. 53 (1884); Final report in Vol. 14, p. 475 (1885).

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M. Deval, "Measurement of Variation in Volume of Hydraulic Cements," *Bulletin* de la Société d'Encouragement, Vol. 5, January, 1900, pp. 31–54.

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Engineers, U.S.A. War Dept., Board on Specifications for Cement, "Testing Hydraulic Cements," *Professional Papers 28*, Second Edition, U. S. Corps of Engineers, p. 14 (1901).

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Shiffner, "Determination of the Soundness of Portland Cement," *Engineering Record*, Vol. 45, January 18, 1902, p. 56. (Taken from *Proceedings*, German Portland Cement Mfrs. (1901).)

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F. W. Taylor and S. E. Thompson, "Testing the Soundness of Cement," *American Architect*, Vol. 81, July 18, 1903, pp. 19–20.

Considers methods advocated by American Society of Civil Engineers and outlines several other methods.

W. P. Taylor, "Soundness Tests of Portland Cement," *Proceedings*, Am. Soc. Testing Mats., Vol. III, p. 374 (1903); *Engineering News*, July 23, 1903, p. 81.

Normal and accelerated tests for soundness on pats, cakes and briquets of neat cement. Soundness is a test for permanency of a cement which is as important a factor as strength. Causes of unsoundness and methods of overcoming it in certain cases described. Soundness tests at 1, 2, 3 and 5 weeks in air, in water and in boiling water and for cements of different finenesses. Tensile strength tests of neat cements which failed and passed the boiling test indicate that the former shows higher early strengths. The opposite is true of the 1:3 mortars. Examples of unsoundness photographed.

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1. Higher silica, better cement boils,
2. Higher the oxide of iron, better cement boils,
3. Within certain limits, the higher the sulphuric acid, the better cement boils, and
4. Within limits of approved formula, higher the lime, the better cement boils.

Magnesia appears to be entirely inert. Constitution of cements of boiling quality given.

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Contents.—Reasons for Such Tests; The Origin of the Boiling Test; Tests by Tetmajer, Maclay, Erdmenger, Prüssing, Heintz, Faija; Results obtained by Accelerated Tests; Verdict in Germany and America as to the Value of These Tests.

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A. Davis, "Unreliability of Cold Plunge Test for Cement," *Railway and Engineering Review*, Vol. 50, January 20, 1910, pp. 79–80.

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M. Gary, "Discussion of Building Grades Association (Constancy of Volume and Time of Setting)," *Zentralblatt der Bauverwaltung*, Vol. 30, March 9, 1910, pp. 136–140.

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sound after subjection to boiling at 20 atmospheres pressure for 2 hr. Description of test given.

R. Feret, "Experiments on Control of Le Chatelier Test," *Génie Civil*, Vol. 61, p. 128 (1912).

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B. Enright, "Autoclave Boiling Test for Cement," *Engineering News*, Vol. 68, August 8, 1912, p. 263.

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H. Kühl, "Cause of Unsoundness in Cement," *Tonindustrie Zeitung*, Vol. 36, p. 1331 (1912).

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H. J. Force, "Preparing Solid Blocks of Portland Cement," U. S. Patent 1,058,977, February 3, 1914.

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Report of Subcommittee on Accelerated Tests of Cement, *Proceedings*, Am. Soc. Testing Mats., Vol. XV, Part I, p. 147 (1915).

Autoclave test does not show appreciable merit as test for soundness.

R. J. Wig and H. A. Davis, "Value of the High Pressure Steam Test of Portland Cements," National Bureau of Standards *Technologic Paper No. 47* (1915).

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Data Considered by A.S.T.M. Committee C-1 in Preparing the Standard Specifications and Tests for Portland Cement, Published by Committee C-1, July, 1919, p. 118. (Separate publication.)

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J. R. Dwyer, "Effect of Age of Test Pieces in Soundness Tests of Portland Cement," *Concrete*, Vol. 17, December, 1920, p. 87.

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Discusses boiling and other tests for cement, experiments carried out, improvements caused by storage in water, unsoundness of cement and its prevention.

S. Kano, "Accelerated Tests of Portland Cement," *Journal*, Am. Ceramic Soc., Vol. 5, November, 1922, p. 295.

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Hans Kühl and Albert, "Effect of Temperature on Unsoundness of Portland Cement Due to Calcium Sulfate," *Zement*, Vol. 12, pp. 201, 210 (1923).

Test pieces of cement ground with 2, 10 and 20 per cent calcium sulfate, stored in water at 0 to 100 C. up to 91 days. Tested for tensile strength and soundness. Unsoundness explained by Kühl's theory of "crystallization pressure," calcium sulfo-aluminate taking place of lime.

Hans Kühl and Albert, "Effect of Temperature on Formation of Calcium Sulfo-Aluminate," *Zement*, Vol. 12, pp. 279, 285 (1923).

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1925

Long-Time Tests of Unsound Cement, National Bureau of Standards *Technical News Bulletin No. 96*, April 10, 1925; *Concrete*, Vol. 26, May, 1925, p. 177.

Compressive strength tests on $1:1\frac{1}{2}:3$ concrete and tensile strength of 1:3 standard sand briquets under different storage conditions tested at 6 yr.

Hans Kühl and Erich Ullrich, "Unsoundness of Cement Due to Chlorine," *Zement*, Vol. 14, October 22, 1925, p. 859; October 29, 1925, p. 880; November 5, 1925, p. 898.

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B. Yokoyama, "New Accelerated Test for Soundness of Portland Cement," *Journal*, Japan Ceramic Assn., Vol. 35, p. 107 (1927).

A paste of normal consistency is molded for measuring with Le Chatelier's calipers. It is placed between glass plates, kept 2 hr. at 15 to 25 C., then in an air bath at 35 to 40 C. for 4 hr., and finally in boiling water for 20 min. Expansion should not exceed 3 mm.

Nat. Bureau of Standards, "Expansion of Neat Portland Cement in Steam," *Journal*, Franklin Inst., Vol. 204, October, 1927, p. 531.

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F. Schott, "Cracking of Glass Plates Caused by Normal Cement Pats," *Zement*, Vol. 17, pp. 1145, 1169 (1928).

Cracking occurred, not because of contraction of the paste nor the difference in coefficient of expansion of the cement and glass, but because the pat adhered to the glass plate, except where the tensile strength of the glass was very high. Unsound cements did not usually adhere to the plate, and for this reason it is suggested that a test for unsoundness be developed on that basis.

A. Dahlgren, "Cement Soundness," *Revue de matériaux de construction et de travaux publics*, No. 228, September, 1928, p. 331.

Main causes of unsoundness and expansion caused by formation of calcium hydroxide crystals during setting. Heintz's ball method of testing soundness, and White's phenol method of determining free lime

P. Feron, "Unsoundness and Its Control," *Revue de matériaux de construction et de travaux publics*, p. 361 (1928).

Cements containing 3 to 5 per cent magnesium oxide showed no volume change on boiling 3 hr., but after a second 3 hr., expansion of several millimeters was noted which reached as much as 160 mm. after 18-hr. boiling.

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"Test for Cement Soundness," *Cement and Cement Manufacture*, Vol. 2, May, 1929, p. 129.

A. J. Blank, "Unsoundness Factor in Portland Cement Manufacture," *Rock Products*, Vol. 32, July 6, 1929, p. 72.

Effects of uncombined lime in varying percentages.

William Lerch, "Cause of Unsoundness of Portland Cement," *Concrete* (CMS), Vol. 35, July, 1929, p. 109; August, 1929, p. 115; *Paper No. 20*, Portland Cement Association Fellowship at the National Bureau of Standards (1929).

Factors causing abnormal expansion, cracking, or distortion, which sometimes occur when portland cements are subjected to accelerated tests for unsoundness; contains brief bibliography.

H. Tucker, "Constant-Level Attachment for Soundness Test on Portland Cement," *Engineering News-Record*, Vol. 102, May 9, 1929, p. 765.

E. Shaw, "Investigation of Tests for Soundness," *Rock Products*, Vol. 32, No. 21, p. 66 (1929).

J. Keith, "Methods of Storing Cement Specimens for the Standard Specification Tests and Their Effects upon Strength," *Zement*, Vol. 18, No. 4, p. 94 (1929); *Building Science Abstracts*, Vol. 2, March, 1929, p. 113.

Investigation carried out to study contentions of Gensbaur reveals that in most cases loss of strength relative to the results given by the German standard combined storage are intimately connected with the soundness of the cement, that the "KL" storage is therefore a severe soundness test, and further that the practice of increasing the lime content of portland cements for the purpose of achieving great compressive strength results in loss of strength in "KL" storage, and thus in the structure.

A. Alexandrov, "Physico-Chemical Principles Underlying the Methods of Testing the Consistency of Volume of Portland Cement," *Journal of Applied Chemistry* (Leningrad), Vol. 2, p. 303 (1929); *Chemical Abstracts*, Vol. 33, p. 4547 (1929).

Changes in the composition of portland cement on aging discussed. Experimental work showed that Faija's method of testing soundness of cement is not sufficiently severe. Heintz's method and drying at 120 F. bear no definite relationship to the properties of cement and should be discarded as misleading. Boiling in water results in hydration of the cement and though the process is not exactly the same as encountered in aging under normal conditions, its use can be recommended. These methods show that the Le Chatelier is most exact. Drying at 120 F. followed by steam treatment is very promising, but considerably more work must be done before this method becomes practical.

G. Haegermann, "Why Cement Specimens Crack and Scale in Cold Water Testing," *Zement*, Vol. 18, p. 36 (1929).

1930

H. Lafuma, "Theory of the Expansion of Hydraulic Cements," *Revue de matériaux de construction et de travaux publics*, No. 243, p. 441 (1929); No. 244, p. 4 (1930); *Building Science Abstracts*, Vol. 3, March, 1930, p. 85.

Author resents theoretical discussion of causes of unsoundness in certain hydraulic cements and of the mechanism of the destruction of cement and concrete by sulfate action.

H. Burchartz, "Occurrence of Radial Cracks in Cement Pats Stored in Air After Previous Storage in Water," *Zement*, Vol. 19, No. 12, p. 265 (1930); *Building Science Abstracts*, Vol. 3, April, 1930, p. 127.

Investigation of radial shrinkage cracks which frequently appear in cement pats prepared for the cold water soundness test after they have been removed from the water and which are occasionally mistaken for indications of unsoundness.

H. Kühl, "The Cement Moduli," *Tonindustrie Zeitung*, Vol. 54, No. 23, p. 389 (1930); *Building Science Abstracts*, Vol. 3, September, 1930, p. 300.

Conclusions of Schott and of Lerch on the soundness of tricalcium silicate and tricalcium aluminate.

G. Haegermann, "The Testing of Cement," *Cement and Cement Manufacture*, Vol. 3, January, 1930, p. 69.

Discussion of soundness, setting time and strength tests; method of curing, specifications, methods of mixing and molding test specimens in various countries.

"Soundness Testing," *Tonindustrie Zeitung*, Vol. 54, November 2, 1930, p. 1388.

Abstracted from supplement to German tentative specification for portland cement, iron portland cement, and blast-furnace cement.

G. Haegermann, "Free Lime and the Soundness of Portland Cement," *Zement*, Vol. 19, October 16, 1930, p. 982; *Journal*, Am. Concrete Inst., Vol. 2, No. 4, p. 94 (1930).

Twelve different technical raw meals burned in resistance furnace under similar conditions to various temperatures between 1225 and 1475 C. Free lime determined by Emley's method and samples ground and tested for soundness by boiling test and 28-day cold water test. Products obtained differed considerably in free lime content, depending on composition and fineness of initial grinding. Judging from the boiling test, cements containing 1 per cent free lime are sound (in extreme cases 2 per cent). Upper limit of free lime passed as sound by cold water test is 4 per cent.

"How Gypsum Content May Affect Soundness," *Concrete*, Vol. 37, November, 1930, p. 40.

A. Guttman, "Free Lime, Soundness and Strength," *Mitteilungen* aus dem Forschungs-Institut Verein Deutscher Eisen - Portland-Zement Werke (Düsseldorf), (1930); *Zement*, Vol. 19, November 13, 1930, p. 1078.

Results of tests of clinkers burned under different conditions with varying compositions led author to agreement, in general, with conclusions of Haegermann concerning quantitative relation between content of lime in cement and its behavior in cold water and under boiling test; reduction of free lime in clinker was always accompanied by remarkable decrease in tensile strength.

1931

H. Vierheller, "Flaking of Cement Pats in Water," *Tonindustrie Zeitung*, Vol. 55, No. 86, p. 1197 (1931); *Building Science Abstracts*, Vol. 3, November, 1931, p. 375.

Refers to E. Rissel's study of flaking of cement pats in cold water, author states that practically all aluminous cement pats flake in cold water, but that unsoundness is not necessarily indicated.

F. F. Tippmann, "Hardening of Portland Cement," *Cement*, Vol. 4, No. 10, p. 1115 (1931); *Building Science Abstracts*, Vol. 3, December, 1931, p. 415.

Unsoundness due to presence of calcium sulfate is caused by excessive crystallization of calcium hydroxide. Possible to remove unsoundness due to lime by addition of gypsum which causes crystallization of any amorphous calcium hydroxide formed during setting.

O. Goffin and G. Mussgnug, "Effect of Gypsum on Soundness of High-Limed Clinker," *Cement*, Vol. 4, No. 12, p. 1344 (1931); *Building Science Abstracts*, Vol. 5, January, 1931, p. 15.

G. Haegermann, "Preliminary Testing of Cement According to Section 8 of the New German Standard Specification," *Zement*, Vol. 20, December 3, 1931, p. 1032. Abstracted in *Journal*, Am. Concrete Inst., Vol. 3, February, 1932, p. 146.

K. Koyanagi, "Free Lime in Portland Cement Clinker and Soundness of Cement," *Rock Products*, Vol. 34, March 28, 1931, p. 74.

Experiments on (1) degree of burning of portland cement clinker and free lime; (2) mixing unsound cement and sound one; (3) decrease in content of free lime and increase in soundness during the storage of cement. Soundness determined by water test and modification of Le Chatelier test.

A. J. Blank, "Some Observations and Data in Connection with Manufacture of Portland Cement from Raw Materials and Fuels High in Sulfur Content," *Rock Products*, Vol. 34, April 11, 1931, p. 64.

Manufacture of cement with materials and fuels high in sulfur compounds resulting in sulfides in clinker; sulfur present as sulfide causes unsoundness in cements of much more dangerous character than unsoundness by free lime.

W. J. Pitt, "Free Lime in Portland Cement," *Chemical Engineering and Mining Review*, Vol. 23, p. 227 (1931); *Chemical Abstracts*, Vol. 25, p. 3798 (1931).

Free lime is responsible for unsound cement. Assertion that cement which has been seasoned until sound is just as good as one which was sound when freshly made, is erroneous. However, when condition is not severe, it can be cured by storage. Water added to clinker as it leaves kiln is said to convert free lime into calcium hydroxide, but where much uncombined calcium oxide is present, it is best to store the batch until seasoned. Tests showing failure due to free lime are described.

K. Koyanagi, "Causes of Discoloration of Clinker and Its Effect on Soundness and Strength," *Rock Products*, Vol. 34, September 12, 1931, p. 68.

Discolored clinker by quenching contains little ferrous oxide and resulting cement is quite sound; that discolored by direct reduction contains much ferrous oxide and resulting cement becomes unsound and shows much lower strength than normally burned cement; discolored clinker by over-burning also contains much ferrous oxide, but cement is quite sound and gives very good strength.

H. Luftschitz, "Problem of the Boiling Test," *Zement*, Vol. 20, June 18, 1931, p. 585. Abstracted in *Cement and Cement Manufacture*, Vol. 5, February, 1932, p. 81.

Phenomena occurring when cement pats are exposed to boiling water, steam or hot air were critically examined and a theory explaining their behavior was derived.

K. Koyanagi, "Content and Soundness of Cement with Raw Materials High in SO_3," *Rock Products*, Vol. 34, October 10, 1931, p. 72.

1932

A. C. Davis, "Constancy of Volume of Portland Cement," *Cement*, Vol. 5, No. 7, p. 253 (1932).

General description of various methods of testing soundness of portland cement.

E. Rissel, "The Value of the Boiling Test in the Control of Cement," *Tonindustrie Zeitung*, Vol. 56, February 29, 1932, p. 249.

Critical consideration of valuation of cements by boiling tests. Effect of form of pats, amount of mixing water, time and temperature of storage stressed. Experiments cited where unsound cements passed boiling test judged according to specifications.

G. Haegermann, "Preliminary Tests of Cements of New German Standard Specification," *Cement and Cement Manufacture*, Vol. 5, March, 1932, p. 91.

Preliminary tests for setting time and soundness, finger nail test and boiling test, respectively.

O. Goffin and G. Mussgnug, "Uncombined Lime in Portland Cement Clinker," *Zement*, Vol. 21, March 17, 1932, p. 145; March 31, 1932, p. 178; *Building Science Abstracts*, Vol. 5, June, 1932, p. 191.

Close relationship between uncombined lime and soundness; clinkers with uncombined lime up to 2 per cent pass standard soundness tests. High content unfavorable for tensile strength. Up to 4.8 per cent increases compressive strength slightly after 1 to 3 days. Degree of burning estimated from chemical composition and uncombined lime content.

P. H. Bates and R. L. Blaine, "Notes on Hardening Cements at Boiling Point of Water," *Journal*, Am. Concrete Inst., Vol. 3, April, 1932, p. 531. Abstracted in *Rock Products*, Vol. 35, June 4, 1932, p. 53.

High early strength portland, one made from cement rock in Lehigh Valley, the third from marl and clay, and the fourth from limestone and clay.

C. H. Lovejoy, "Keeping Constant Boiler Water Level in Test of Cement," *Rock Products*, Vol. 35, June 4, 1932, p. 37.

Device is an adaptation of the ordinary 5-gal. bottle drinking fountain used in offices. As water in boiler used for soundness tests on cement boils away it is replaced from bottle by reason of a difference in level.

A. C. Davis, "Constancy of Volume of Portland Cement," United States Tests for Soundness, *Cement and Cement Manufacture*, Vol. 5, No. 7, July, 1932, p. 255.

G. E. Bessey, "Production of Free Lime in Portland Cement by Heating," *Cement and Cement Manufacture*, Vol. 5, No. 7, p. 233 (1932).

G. A. Ashkenasi, "Behavior of Portland Cement when Heated," *Cement and Cement Manufacture*, Vol. 5, No. 7, p. 240 (1932).

Results of further studies on liberation of free lime from cements on heating at 1000 C. Gypsum accelerates reactions but tricalcium phosphate retards them. Cements which have been heated for long periods at 1000 C. become unsound and have very low tensile strength as compared with the original cement. As an explanation for the increase in free lime on heating as above, suggested that the cement contains the lime in solid solution in $2CaO \cdot SiO_2$ and that on prolonged heating the lime is released from this solid solution.

1933

K. Balthasar, "High Magnesia Cements Show Ample Soundness," *Tonindustrie Zeitung*, Vol. 25, October 27, 1932, p. 79. Abstracted in *Pit and Quarry*, Vol. 25, January, 1933, p. 78.

G. E. Bessey, "Free Lime in Portland Cement," *Cement and Cement Manufacture*, Vol. 6, September, 1933, p. 297.

Methods of determination; cause of presence of free calcium oxide in cement; presence of free calcium hydroxide in cement; free lime and unsoundness in cements.

F. Thilo, "Influence of Alumina Modulus upon the Unsoundness of Portland Cement Caused by an Excess of Calcium Sulfate," *Mitteilungen* aus dem Zementtechnischen Institut der Technische Hochschule (Berlin), No. 43, (1933); *Zement*, Vol. 22, No. 20, p. 261 (1933); *Building Science Abstracts*, Vol. 6, September, 1933, p. 298.

Concluded from study of results that occurrence of calcium sulfate unsoundness caused by formation of calcium sulfo-aluminate is dependent upon presence of free aluminates, and that presence of combined alumina as Brownmiller's compound does not give rise to unsoundness. Cannot yet be decided whether high calcium sulfate content will always cause structural disintegration in course of time, or whether its presence will merely favor attack by sulfate waters. Considered that no deterioration of cements exposed to sulfate waters need be apprehended if they contain a molecular excess of ferric oxide over alumina.

A. E. Hiscox, "Steam Test of Portland Cement Mortar Briquets," *Rock Products*, Vol. 36, September, 1933, p. 34; *Building Science Abstracts*, Vol. 6, December, 1933, p. 416.

1934

R. H. Bogue, William Lerch and W. C. Taylor, "Portland Cement Pastes—Influence of Composition on Volume Constancy and Salt Resistance," *Industrial and Engineering Chemistry*, Vol. 26, October, 1934, p. 1049; *Paper No. 28*, Portland Cement Association Fellowship at the National Bureau of Standards (1934).

Report of Working Committee on Volume Change and Soundness of Portland Cement, *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, p. 356 (1934); *Building Science Abstracts*, Vol. 7, June, 1934, p. 245.

H. Kühl and Meyer, "High Magnesia Cements," *Tonindustrie Zeitung*, Vol. 58, Nos. 1, 3 and 4 (1934).

H. E. Schwiete and H. Zur Strassen, "Combination of Magnesia in Portland Cement," *Zement*, Vol. 23, No. 9, p. 113 (1934).

Unsoundness due to free magnesia.

1935

A. J. Blank, "Cause of Unsoundness of Cement," *Concrete* (CMS), Vol. 43, June, 1935, p. 38.

Review of the literature; conclusions formed from experience in manufacturing cements from a variety of materials, at a number of plants. 51 references.

DISCUSSION

Mr. Ira Paul[1] (*presented in written form*).—Referring to the Report of the Working Committee on Volume Change and Soundness of Portland Cement, the results of a number of autoclave soundness tests made by the writer are presented. During the past year the writer made about 200 autoclave expansion tests on portland cements, high-early-strength cements, natural cements, portland cement blends with natural cement, and in addition carried on some tests on mortars and concrete specimens.

The test specimens were 1-in. square bars, 10 in. in length, made of neat cement. Upon removal from molds (20 to 24 hr. after casting) the specimens were placed in water at 70 F. for 1 hr., then surface dried and measured for initial length. The specimens were then placed in the autoclave, and the steam pressure was raised to 300 lb. (420 F.) during a period of 1 hr. This pressure of 300 lb. was maintained for 5 hr., followed by a cooling period of 18 hr. Specimens were then removed from the autoclave, again placed in water at 70 F. for 1 hr., then surface dried and measured for length. The difference between the final length and initial was recorded and the percentage of expansion or contraction calculated. Duplicate specimens were made on each of the tests, and the average is reported in the accompanying Tables I and II.

From a detailed study of Table I it will be noted that there is no relationship between the free lime content in the cement and the autoclave expansion test results. Although samples Nos. 1 and 2 showed no free lime, the expansion on sample No. 1 was +0.59 per cent while sample No. 2 had +0.05 per cent expansion. Samples Nos. 3 and 4 showed over 3 per cent free lime yet No. 3 expanded only +0.05 per cent while sample No. 4 showed an expansion of +0.62 per cent. In my experimental portland cements, Nos. 8x and 38x had 3.71 per cent and 3.84 per cent free lime respectively while the autoclave tests showed that sample No. 8 expanded only +0.35 per cent and No. 38x had an expansion of 4.78 per cent. Two other samples of cement Nos. 17 and 34x both disintegrated in the autoclave test while the free lime showed in the one case 13.8 per cent and in the other only 2.42 per cent. To try to correlate the free lime content of a cement with its expansion in the autoclave is futile because the free lime determination does not differentiate the lime present in a free state from that present in the form of calcium hydrate. Secondly, free lime in either form may be present in the cement originally and through carbonation by contact with CO_2 in the air will be converted to $CaCO_3$ which will not be detected in the free lime determination.

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[1] Associate Laboratory Engineer, New York State Department of Public Works, Albany, N. Y.

An attempt was made to correlate the autoclave expansion test results with the potential C_3A content in the cement. While there were some indications that this could be done, there were a good many exceptions. Cements having a C_3A content of less than 9 per cent showed somewhat lower expansion tests than those of higher C_3A content. However, there were some cements with C_3A content of 15 per cent that had the same low autoclave expansion results as those below 9 per cent C_3A. A sample of cement with only 6 per cent C_3A completely disintegrated in the autoclave test.

TABLE I.—RESULTS OF AUTOCLAVE SOUNDNESS TESTS ON VARIOUS CEMENTS.

Sample	Free CaO, per cent	C_3A, per cent	MgO, per cent	Expansion in Autoclave Test, per cent
No. 1	Nil	15.1	3.34	+0.59
No. 2	Nil	7.4	2.92	+0.05
No. 3	3.44	7.3	3.76	+0.05
No. 4	3.22	14.0	3.26	+0.62
No. 5	0.66	14.5	3.5	+0.84
No. 6	0.34	15.6	3.0	+0.32
No. 7	0.46	12.4	3.32	+0.46
No. 8	0.67	13.7	3.3	+0.11
No. 9	1.55	14.9	2.7	+0.51
No. 10	1.62	14.7	3.4	+0.20
No. 11	1.75	12.4	3.32	+0.46
No. 12	1.55	12.5	2.32	+0.13
No. 13	1.89	15.7	3.22	+0.69
No. 14	2.56	14.7	3.25	+0.62
No. 15	1.01	7.8	1.68	+0.15
No. 16	1.75	8.1	2.01	+0.26
No. 17	13.80	14.0	3.41	Disintegrated
No. 34x	2.42	6.4	1.67	Disintegrated
No. 8x	3.71	9.6	3.20	+0.35
No. 38x	3.84	13.9	2.66	+4.78
No. 14x	5.80	9.8	3.02	+12.0
No. 16x	12.55	12.4	2.67	+8.31
No. 40x	0.13	14.5	2.85	+0.20

TABLE II.—RESULTS OF AUTOCLAVE SOUNDNESS TESTS ON VARIOUS CEMENTS.

Sample	Free CaO, per cent	C_3A, per cent	MgO, per cent	Expansion in Autoclave Test, per cent
No. 17	13.80	14.0	3.41	Disintegrated
No. 18	1.89	15.7	3.22	+0.49
No. 19	....	7.1	1.28	+0.003
No. 1N	1.00	....	20.31	+10.0
No. 2N	0.46	....	21.81	+0.33
No. 3N	....	....	14.02	+9.66
75 per cent No. 18 + 25 per cent No. 17				+0.43
75 per cent No. 19 + 25 per cent No. 17				+0.036
75 per cent No. 18 + 25 per cent No. 1N				+0.73
75 per cent No. 19 + 25 per cent No. 1N				+0.13
75 per cent No. 18 + 25 per cent No. 2N				+0.50
75 per cent No. 19 + 25 per cent No. 2N				+0.12

Three natural cements were tested in the autoclave. Two that were made in upright kilns showed about 10 per cent expansion while the third made in a horizontal rotary kiln had only 0.33 per cent expansion. Blends of these two types of natural cement with two different brands of portland cement show slightly higher results in autoclave than the original portland cement, but the difference apparent in the original natural cements was lost in the test results obtained in the blends (Table II).

Cement No. 17, which was an underburned portland cement, having a free lime content of 13.8 per cent, completely disintegrated in the autoclave test. A blend of 25 per cent of this cement with a normal portland cement showed a lower expansion result than the original normal portland cement (Table II).

REPORT OF SUBCOMMITTEE ON CEMENT REFERENCE LABORATORY

(Period April 1, 1935, to March 31, 1936)

Laboratory Inspection Tours:

The fourth tour of inspection of cement testing laboratories was completed in the late summer of last year, field inspections of 86 laboratories being made during the period covered by this report. The total number of laboratories covered in the fourth inspection tour was 229, among which were 17 laboratories which had not been previously visited.

A fifth inspection tour, to be started soon, was announced early in February and the requests received thus far for this inspection service represent 239 laboratories, of which 14 have not been inspected in earlier tours. The classification of laboratories which participated in the fourth tour of inspection as well as those laboratories which have requested inspection in the fifth tour is as follows:

Interest	Number of Laboratories Inspected in Fourth Tour	Number of Laboratories To Be Inspected in Fifth Tour
Cement producers	100	106
Commercial testing laboratories	37	35
State highways[a]	61	61
Schools	13	17
Municipal	6	9
Miscellaneous	12	11

[a] Includes highway branch laboratories, some of which are located at cement mills.

There have been sent to the U. S. Bureau of Public Roads copies of more than 90 reports covering inspections made at laboratories making acceptance tests of cement for Federal Aid projects.

The report submitted by this subcommittee for the preceding year[1] presented tables comparing the percentages of the various apparatus approved during the different laboratory inspection tours and comparing the percentages of each test method detail which had been found in accordance with requirements. The figures given for the fourth tour in this previous report were based on inspections of 143 laboratories. These comparative data have since been extended to include all of the 229 laboratories inspected during the fourth tour. For that tour, the percentages of satisfactory apparatus remain substantially the same as given in Table I in last year's report, while the figures illustrating test method details will not greatly differ in general from the corresponding figures in Table II of the 1935 report. Therefore, the revised tables are not presented in this report. However, emphasis is laid on the fact that in the fourth tour, just as in earlier tours, the percentages of test details conforming to standard requirements were relatively low for the few laboratories which were inspected for the first time when compared with those laboratories which had had one or more prior inspections.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 236 (1935).

Studies of Test Apparatus:

An effort has been made at the Reference Laboratory to design an apparatus which would be not only indicative of the relative workability of mortars but would also serve as a mixer for the small batches required for cube tests. Based on the experimental work already done with a number of different designs of equipment, a new apparatus was constructed and studies are now being continued.

Occasional criticism has been received relative to the stirring apparatus for dispersing the sample when making a fineness test with the Wagner turbidimeter. Some comparative studies have been made, with encouraging results, in the endeavor to devise a stirrer which would prove more satisfactory than the usual brush, and which could be more accurately duplicated. The question of speed of rotation of stirrer, not sufficiently covered by the present Tentative Method of Test for Fineness of Portland Cement by Means of the Turbidimeter (C 115 – 34 T), is also being studied. As soon as a new motor better suited for these studies has been received, additional work will be done, and it is hoped that recommendations for improvement along these lines can be made soon. One member of the staff devoted some time to comparative studies of fineness tests made on special blended cements, using two different types of apparatus.

Much time was devoted to studying proposed methods of examining 2-in. cube molds for compliance with the requirements of the Tentative Method of Test for Compressive Strength of Portland-Cement Mortars (C 109 – 34 T), and this matter has been discussed with the Working Committee on Plastic Mortar Tests for Portland Cements. In order to secure actual data on the effect on compressive strength of 2-in. cubes resulting from various degress of departure from planeness in the bearing surfaces, there was carried out a recently completed program of tests. A large number of 2-in. cubes, formed in molds which had interior surfaces well within the requirements of the present tentative method, were tested at four different ages and under seven different conditions of bearing blocks. As the basis of comparison, some of the cubes were tested between plane surfaces. Other cubes were tested between blocks which had spherical faces—some convex and some concave. Under each of the latter conditions there were three different degrees of departure from planeness, 0.001, 0.002 and 0.004 in. in a gage length of 2 in. The data of these tests, which have just now been completed, are now being assembled into a report, which should be helpful in considering requirements for planeness of bearing blocks and mold surfaces and which is intended for presentation as a paper at the June meeting.[1]

The first of a series of comparative tests on samples of cement to be distributed by the Reference Laboratory was recently announced. Approximately 50 laboratories were approached in connection with this first sample and acceptances have been received from practically all of them. The sample will go forward at a very early date.

The need of specifications for, and inspections of, newly purchased cement testing apparatus is well illustrated by the experience with some equipment which was received within recent months at the bureau for test. A cement tension testing machine, fairly satisfactory as to accuracy, was slightly adjusted by the staff in order to secure more satisfactory general operation, but was still not acceptable because of poorly fitting threads on the adjustment block under the lower grips. This part was replaced and the manufacturer also submitted a more satisfactory weighing device. A Vicat apparatus and Gillmore needles were found unsatisfactory by the laboratory because of lack of attention to minor details. One lot of briquet molds submitted on a Bureau purchase order was found unsatisfactory for outline. The lot submitted as replacement, and also a lot submitted by another purchaser, were very unsatisfactory with regard to the interior surfaces of the briquet pockets. These surfaces were extremely rough and, in many places, their elements were far from straight lines.

Respectfully submitted on behalf of the subcommittee,

G. E. WARREN,
Chairman.

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[1] J. R. Dwyer, "Effect of Departure from Planeness of Bearing Surfaces on the Compressive Strength of Two-Inch Mortar Cubes," *Proceedings*, Am. Soc. Testing Mats., Vol. 36, Part II, p. 351 (1936).

APPENDIX

PROPOSED METHOD FOR DETERMINING PHOSPHORUS AND MANGANESE IN CEMENT[1]

This is a **proposed draft** and is published as information only. Comments are solicited and should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

DETERMINATION OF PHOSPHORUS

1. *Solutions Required.*—The following solutions will be required:

(*a*) *Ammonium Molybdate Solution.*—Dissolve 100 g. of molybdic acid (85 per cent of MoO_3) in a mixture of 400 ml. of water and 100 ml. of ammonia water (sp. gr. 0.90) and cool the solution to room temperature. Pour this solution very slowly and with constant stirring, into a cooled mixture of 600 ml. of water and 400 ml. of HNO_3 (sp. gr. 1.42). No permanent precipitate should form, which does not redissolve with stirring. Add one drop of saturated sodium ammonium phosphate solution, shake thoroughly and allow to stand at least 24 hr. before using. Filter portions of the solution before use.

(*b*) *Magnesia Mixture.*—Dissolve 50 g. of $MgCl_2 \cdot 6H_2O$ and 100 g. of NH_4Cl in 500 ml. of water. Add NH_4OH in slight excess, let stand overnight. Filter, acidify with HCl, and dilute to 1 liter.

2. *Procedure.*—Phosphorus shall be determined as follows:

(*a*) Weigh a 1.0-g. sample of the cement into a 250-ml. beaker. Treat the sample with 50 ml. of water and then with 10 ml. of HNO_3 (sp. gr. 1.42). Boil until solution is as complete as possible. To samples containing manganese a few milliliters of 5 per cent potassium nitrite solution may be added during the boiling, to aid in the solution. Boil until all brown nitrous fumes are expelled, taking care not to allow the volume of the solution to become so small as to cause the precipitation of silica. Then filter and wash.

(*b*) To the solution, in a 500-ml. Erlenmeyer flask, which should have a volume of about 150 ml., add 10 g. of ammonium nitrate and warm until in solution. Then heat the solution to 85 C. and add 50 to 100 ml. of ammonium molybdate solution (depending on amount of phosphorus present). Stopper the flask, shake vigorously for 5 min. and set aside to settle for 30 min. Filter through a double 9-cm. paper, rinsing the flask five times and washing the paper eight times with a cold solution of potassium nitrate (1 per cent).

(*c*) Put the flask in which the precipitation was made under the funnel containing the precipitate. Then pour over the precipitate and around the upper edges of the paper a mixture of 5 ml. of concentrated ammonia and 20 ml. of water, until the precipitate is entirely dissolved. Wash the paper three times with cold water, twice with HCl (1:1), and finally three times with cold water. If not already acid, make the filtrate slightly acid with HCl and add 4 or 5 drops of a saturated citric acid solution to hold any small traces of iron in solution. Then cool to room temperature, and transfer the solution to a 400-ml. beaker. The volume of the solution should now be about 150 ml. Add 25 ml. of magnesia mixture, and then, drop by drop with constant stirring, 50 ml. of ammonia water (sp. gr. 0. 90) at such rate that 5 min. are required for the addition. Allow to stand 4 hr. or longer, filter, and wash a few times with dilute ammonium hydroxide (1:20). Dissolve the precipitate in 25 ml. of dilute HCl (1:1), catching the solution in the original beaker. Wash the filter thoroughly with dilute HCl (1:20), dilute the solution to 50 to 100 ml. and add 1 to 2 ml. of magnesia mixture. Add ammonium hydroxide slowly and with constant stirring as before. Allow to stand 2 hr. or longer, filter, scrub the beaker, and wash ten times with dilute ammonium hydroxide (1:20). Ignite in a weighed crucible, and weigh as $Mg_2P_2O_7$, which multiplied by 0.6379 gives the weight of the phosphorus in the sample as P_2O_5.

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[1] Under the standardization procedure of the Society, this proposed method is under the jurisdiction of the A.S.T.M. Committee C-1 on Cement.

(*d*) *Blank Determination.*—Make a blank determination, using the same procedure as outlined above and using approximately the same amounts of reagents. Correct the weight of $Mg_2P_2O_7$ accordingly.

DETERMINATION OF MANGANESE

3. *Solution Required.*—The following solution will be required:

Standard Sodium Arsenite Solution.—Prepare the solution by dissolving 3.0 g. of sodium carbonate in about 100 ml. of water and then adding 0.9008 g. of arsenious oxide (As_2O_3). Heat on the hot plate until solution is as complete as possible, filter if necessary, and cool to room temperature. Transfer to a volumetric flask and dilute to 1 liter. Each milliliter of this solution is approximately equivalent to 0.0004 g. of Mn_2O_3.

Prepare a potassium permanganate solution containing approximately 0.58 g. of $KMnO_4$ per liter, and standardize it against 0.0300 g. of sodium oxalate (National Bureau of Standards Sample No. 40c). The sodium oxalate value of 1 ml. of the permanganate solution multiplied by 0.236 gives its Mn_2O_3 value. Then run 30 ml. of permanganate solution into a 250-ml. Erlenmeyer flask, add 60 ml. of HNO_3 (1:4) and 10 ml. of 5 per cent potassium nitrite solution. Boil for a few minutes to expel nitrous fumes, cool, add sodium bismuthate, and finish with a sodium arsenite titration as described for the determination of manganese in a cement sample (Section 4 (*b*)). Calculate the Mn_2O_3 value of the arsenite solution as follows:

$$Mn_2O_3 \text{ value of 1 ml. of arsenite solution} = \frac{0.03 \times 0.236 \times 30}{a \times b}$$

where a = milliliters of permanganate for 0.0300 g. of sodium oxalate, and
b = milliliters of arsenite solution for 30.0 ml. of permanganate.

4. *Procedure.*—Manganese shall be determined as follows:

(*a*) To a 1.0 to 3.0-g. sample[1] of the cement in a 250-ml. beaker, add 5 to 10 ml. of water and then 60 to 75 ml. of HNO_3 (1:4) and boil until solution is as complete as possible. Then add 10 ml. of 5 per cent potassium nitrite solution and continue the boiling until all brown nitrous fumes are driven off, taking care not to allow the volume of the solution to become so small as to cause the precipitation of silica. This should effect complete solution of the sample, excepting some separated silica. If not, use more potassium nitrite solution. Filter the solution through a rapid 9-cm. qualitative filter into a 250-ml. Erlenmeyer flask, washing several times with hot water. The filtrate should have a volume of 100 to 125 ml.

(*b*) Cool to room temperature and add a total of about 0.5 g. of sodium bismuthate in small quantities at a time, with intermittent shaking. (Note.) Allow the solution to stand for about 5 min., with occasional shaking, and then add 50 ml. of cold HNO_3 (1:33), which has been previously boiled to expel nitrous acid. Filter through a pad of ignited asbestos, in a Gooch crucible or carbon filter, using suction, and wash four times with cold HNO_3 (1:33) (previously boiled). Never use a filter paper for this filtration, as it may cause some reduction of the permanganic acid. Titrate the filtrate immediately with standard sodium arsenite solution, until there is obtained a yellow color free of brown or purple tints and which does not change upon further addition of arsenite.

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[1] The size of the sample depends on the content of manganese in the sample. It may vary from 1 g. for about 1 per cent of manganese to 3 g. for 0.25 per cent or less of manganese.

NOTE.—If the solution contains manganese, it should show the purple color of permanganic acid when the first small quantity of sodium bismuthate is added. If the expected color fails to appear, nitrous acid may not have been completely expelled. To make sure, the solution should be rejected and the work repeated.

(*c*) Calculate the percentage of Mn_2O_3 in the sample by multiplying the titration result by the Mn_2O_3 factor of the sodium arsenite solution times 100 and dividing by the weight of the sample in grams.

REPORT OF COMMITTEE C-3
ON
BRICK

Committee C-3 on Brick has held three meetings during the past year: namely, in Detroit, Mich., on June 27, 1935, in Washington, D. C., on November 14, 1935, and in Pittsburgh, Pa., on March 3, 1936.

Most of the work of the committee has been centered around the activities of its subcommittees. Subcommittee V on Methods of Testing (F. B. Lysle, chairman), and Subcommittee VIII on Clay Building Brick (H. C. Plummer, chairman) have been especially active. These subcommittees have considered revisions of the methods and specifications under their jurisdiction, so that they will as nearly as possible give the consumer and the manufacturer an equitable method for determining the durability and weather resistance of clay building brick.

There have been no recommendations from the subcommittees for revision of the present standards or tentative standards and Committee C-3 accordingly recommends that the specifications and methods of testing under its jurisdiction be continued in their present status.

A paper submitted by Mr. J. W. McBurney entitled, "Water Absorption of Building Brick" is presented in an Appendix to this report. This paper shows the necessity of a rigid specification for the absorption and the importance of strict adherence to the specification.

Several new members have been added to the committee during the year. The present membership of the committee is 36, of whom 15 are classified as producers, 7 as consumers and 14 as general interest members. A new Subcommittee XIII on Glazed and Enameled Brick (H. E. Stringer, chairman) has been organized.

The election of officers for the ensuing term of two years resulted in the selection of J. W. McBurney, chairman; P. H. Bates, vice-chairman, and J. W. Whittemore, secretary.

This report has been submitted to letter ballot of the committee which consists of 36 members; 24 members returned their ballots, of whom 23 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

H. T. Shelley,
Chairman.

J. W. Whittemore,
Secretary.

EDITORIAL NOTE

Subsequent to the annual meeting Committee C-3 on Brick presented to the Society through Committee E-10 on Standards proposed Tentative Specifications for Glazed Building Units and proposed revisions of the Tentative Specifications for Building Brick (Made from Clay or Shale) (C 62 – 35 T) and of the Tentative Methods of Testing Brick (Modulus of Rupture, Compressive Strength, Absorption) (C 67 – 35 T). These recommendations were accepted by Committee E-10 and the new and revised tentative standards appear on pp. 776, 773 and 780, respectively.

APPENDIX

WATER ABSORPTION OF BUILDING BRICK[1]

By J. W. McBurney[2]

Introduction

In the 1935 report of Committee C-3 on Brick,[3] to which was appended a report of Subcommittee XI on Weathering and Porosity, revisions were proposed in the Standard Specifications for Building Brick[4] and Standard Methods of Testing Brick.[5] This report brought about a renewed interest in the determination of absorption of building brick. It soon became evident that various interpretations of the method of testing for absorption were being used by different laboratories. Among the variations possible under a reasonable interpretation of the present tentative methods of testing brick[5] are the use of either dry or previously soaked brick specimens for the 5-hr. boiling test, the use of various lengths of time of immersion in water after completion of boiling, and the use of forced cooling as against slow cooling after boiling. As an illustration of a technique not permissible by the tentative method of test, one laboratory was reported as removing the brick from the boiling water and weighing as soon as cool enough to handle.

The problem in the investigation reported in this paper was not that of determining the "true" absorption. The work here reported was undertaken rather to determine the permissible variation in the methods of test for absorption from the standpoint of reproducibility of results.

The test specimens include both deaired and non-deaired bricks, which types are considered separately.

Non-Deaired Bricks

Selection and Description of Test Specimens:

Records of the tests on 3886 bricks tested in the 1930 survey[6] were examined and 22 half brick specimens were selected for test in the present investigation according to the following criteria: (1) the specimens should represent the maximum range in absorption; (2) all commercial methods of forming should be represented; (3) a variety of raw materials should be selected; and (4) the principal producing districts should be represented.

Application of these rules was modified by the following consideration. Only specimens which could be expected to withstand repeated boilings and dryings without disintegration or loss of weight were selected. This eliminated definite "salmons" as well as bricks from certain districts.

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[1] Publication approved by the Director of the National Bureau of Standards of the U. S. Department of Commerce.

[2] Senior Ceramic Chemist, National Bureau of Standards, Washington, D. C.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 241 (1935).

[4] Tentative Specifications for Building Brick (Made from Clay or Shale) (C 62 – 35 T), *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 788 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 458.

[5] Tentative Methods of Testing Brick (Modulus of Rupture, Compressive Strength, Absorption) (C 67 - 35 T), *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 791 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 461.

[6] J. W. McBurney and C. E. Lovewell, "Strength, Water Absorption and Weather Resistance of Building Bricks Produced in the United States," *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part II, p. 636 (1933).

Table I presents data from the 1930 survey on the 22 brick specimens selected. The water absorptions listed in this table are given for comparison with the results obtained during the present investigation. The fact that in the original determinations, weighings were made only to the nearest 5.0 g. is offered as an explanation of the somewhat erratic results on the specimens having very low absorptions.

After completion of the absorption tests reported in Table I, specimens Nos. 1 to 22 had been stored in barrels from 1932 to 1936. Water had penetrated the barrels and had disintegrated the straw packing, with the result that some of the bricks had become quite dirty and stained. Except for washing in cold water, no attempt was made to prepare the specimens for test No. 1.

TABLE I.—DESCRIPTION OF NON-DEAIRED SPECIMENS.

These data are from the survey made in 1930.
The absorptions were calculated from weighings to the nearest 5.0 g.

Specimens	Manufacturers' Grade Name	Locality	Material[a]	Method of Forming[b]	Kiln[b]	Modulus of Rupture, lb. per sq. in.	Compressive Strength Flat, lb. per sq. in.	Absorption			Ratio, C_{48}/B_5
								5-hr. Cold, per cent	48-hr. Cold, per cent	5-hr. Boiling, per cent	
No. 1	Select white	Wisconsin	C	SC	DD	512	1 830	27.6	29.4	34.1	0.86
No. 2	Stock	Detroit, Mich.	C	SM	Scove	540	3 250	22.0	22.5	25.6	0.88
No. 3	Select all hard	Hudson Valley	C	SM	UD	712	5 840	14.9	15.5	18.6	0.83
No. 4	Kiln run	New Hampshire	C	SM	Scove	1185	7 820	15.1	15.6	18.3	0.85
No. 5	Kiln run	Texas	S	DP	UD	1100	8 970	14.8	16.5	18.2	0.91
No. 6	Arch	Colorado	S	DP	UD	784	4 900	14.3	14.7	17.0	0.86
No. 7	Picked reds	Wyoming	S?	DP	Scove	272	4 420	12.0	12.4	15.8	0.79
No. 8	Medium	Colorado	S	SC	UD	1520	6 840	12.5	13.3	15.2	0.88
No. 9	Common hard	Philadelphia, Pa.	C	EC	Dutch	755	5 980	7.7	8.7	12.1	0.72
No. 10	Common	Cleveland, Ohio	S	SC	Tunnel	650	10 330	7.9	8.5	10.3	0.83
No. 11	Clinker	Richmond, Va.	C	SC	....	1870	8 160	4.3	4.8	8.2	0.58
No. 12	Red face	Alabama	S	DP	DD	1890	15 650	3.7	4.2	6.3	0.67
No. 13	Exterior	Detroit, Mich.	C	SM	DD	2800	8 960	2.2	2.7	3.3	0.82
No. 14	Hard	Alton, Ill.	S	SC	DD	2745	17 250	0.4	0.8	2.8	0.29
No. 15	Full range common	Ohio	Mixed C and S	SC	DD	2610	20 000	0.4	0.4	2.5	0.16
No. 16	Black arch	Baltimore, Md.	C	SC	Dutch	2780	12 280	0.4	0.8	2.4	0.33
No. 17	Kiln run	New Hampshire	C	SM	Scove	2780	8 670	0.5	1.5	2.0	0.75
No. 18	Clinker	Pennsylvania	S	SC	DD	1940	11 200	0.3	0.6	1.9	0.32
No. 19	Reds	Indiana	Mixed C and S	SC	DD	2980	12 850	0.0	0.0	1.8	....
No. 20	Clinker	Cleveland, Ohio	C	SM	Scove	2680	6 200	0.5	0.5	1.0	0.50
No. 21	Clinker	Wisconsin	C	SM	DD	....	15 410	0.0	0.7	0.7	1.00
No. 22	Semi-antique	Ohio	C	SM	DD	3250	17 550	0.0	0.0	0.0	....

[a] C = Clay. S = Shale.

[b] SM = Soft mud. SC = Side cut. DD = Down draft. DP = Dry press. EC = End cut. UD = Up draft.

Methods of Test:

Table II describes the 9 methods used in testing specimens Nos. 1 to 22, inclusive, in the present investigation, in order of application.

Drying.—All bricks were dried in a gas-fired oven with manual temperature control. The temperature was read at the beginning and end of the working day. The 1920 Standard Specifications for Building Brick (C 21 – 20)[1] called for a drying temperature from 107 to 121 C. The 1931 Standard Methods of Testing Brick (Compression, Flexure, Absorption) (C 67 – 31)[1] gives 100 to 105 C. as the drying temperature. The 1935 Tentative Methods of Testing Brick[2] also specify a temperature of 100 to 105 C. for drying. All three methods provide that the bricks shall be dried to constant weight, and apparently it has been the usual practice among lab-

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[1] 1924 Book of A.S.T.M. Standards, p. 665.

TABLE II.—TABULATION OF VARIABLES USED IN DETERMINING ABSORPTION BY 5-HR. BOILING OF NON-DEAIRED BRICK AND SPECIMENS NOS. 23, 24 AND 25 OF THE DEAIRED BRICK.

	Test No. 1	Test No. 2	Test No. 3	Test No. 4	Test No. 5	Test No. 6	Test No. 7	Test No. 8	Test No. 9
Drying time of specimen, days	4	5[b]	5	5	5	5	3	3	7
Temperature, deg. Cent.[a]	102 to 105	85 to 105	105 to 108	105 to 108	105 to 108	100 to 110	110 to 113	102 to 110	115 to 124
Treatment of half brick previous to boiling	48-hr. cold immersion	none	none	none	none	none	48-hr. cold immersion	48-hr. cold immersion	48-hr. cold immersion
Time elapsed between completion of boiling and start of weighing	17 hr.	1 hr.	1 hr.	16 hr.	1 hr.	4 min.[c]	12 hr., 30 min.[d]	17 hr.	1 hr.
Time required for completion of weighing	45 min.	30 min.	1 hr.	1 hr., 15 min.	1 hr.	45 min.	45 min.	45 min.	1 hr., 5 min.
Temperature of water at time of start of weighing, deg. Cent.	25	11	44	32	64	100	27	21	11
Temperature of water at time of completion of weighing, deg. Cent.	25	12	41	30	54	100	26	21	12

[a] Based on 2 daily readings.

[b] Three days in oven with initial temperature of 105 C. which dropped to 85 C. on third day. The specimens were given an additional 2 days at 105 C.

[c] The specimens were removed from the boiling water and weighed after 4 min. in air.

[d] The maximum temperature of the water was 94 C. reached 5½ hr. after starting heating. This temperature was maintained for 5 hr. and the heat was then shut off and cooling occurred during the time indicated.

TABLE III.—WEIGHT IN GRAMS TO NEAREST ½ G. OF NON-DEAIRED HALF BRICKS AFTER DRYING.

Specimen	Test No. 1	Test No. 2	Test No. 3	Test No. 4	Test No. 5	Test No. 6	Test No. 7	Test No. 8	Test No. 9
No. 1	874.5	871.0	872.0	872.5	872.0	873.0	871.5	869.5	869.5
No. 2	955.0	954.0	954.0	953.5	953.0	953.5	953.0	953.5	953.0
No. 3	803.5	802.0	802.0	802.0	802.0	802.0	801.5	801.5	801.0
No. 4	931.5	931.0	931.0	930.5	931.0	931.0	930.5	930.0	930.0
No. 5	882.0	881.0	881.0	881.0	881.0	881.0	880.5	880.5	880.5
No. 6	1088.5	1084.0	1083.5	1083.5	1082.5	1082.0	1081.5	1081.0	1079.5
No. 7	1043.0	1041.0	1040.5	1040.0	1040.0	1039.5	1039.0	1038.5	1038.0
No. 8	1331.5	1328.5	1328.0	1328.0	1328.0	1328.5	1328.0	1328.0	1325.5
No. 9	1036.5	1036.0	1036.0	1036.0	1036.5	1036.0	1036.0	1036.0	1036.0
No. 10	826.0	824.5	824.5	824.0	824.5	824.0	824.0	823.5	823.0
No. 11	1042.0	1042.0	1042.0	1041.5	1042.5	1042.0	1041.5	1041.5	1041.5
No. 12	950.5	950.0	949.5	949.5	949.5	949.0	949.5	949.0	949.5
No. 13	908.5	908.0	908.0	908.0	908.0	908.0	908.0	908.0	908.0
No. 14	1251.0	1251.0	1252.0	1250.5	1251.0	1261.0	1251.5	1257.0	1251.0
No. 15	1187.5	1188.0	1187.0	1187.5	1188.0	1195.0	1187.0	1195.0	1187.5
No. 16	1244.0	1244.0	1244.5	1244.0	1244.0	1252.0	1245.0	1250.0	1244.5
No. 17	1013.0	1012.5	1012.0	1012.0	1012.5	1018.0	1012.5	1012.5	1012.5
No. 18	1811.0	1810.5	1810.5	1810.0	1811.0	1812.5	1811.0	1811.0	1811.0
No. 19	1389.0	1388.5	1389.5	1388.0	1389.0	1395.5	1389.0	1397.5	1389.0
No. 20	1098.5	1098.5	1098.5	1098.0	1098.0	1098.0	1098.0	1098.5	1098.0
No. 21	705.5	705.5	705.5	705.5	705.5	705.0	705.5	705.5	705.5
No. 22	1253.0	1253.0	1252.5	1252.0	1253.0	1253.0	1252.5	1252.5	1252.5
Average Nos. 1 to 11	983.1	981.4	981.4	981.1	981.2	981.1	980.6	980.3	979.8
Average Nos. 12 to 22	1165.1	1164.5	1164.5	1164.1	1164.5	1167.9	1164.5	1166.9	1164.5
Average, all specimens	1074.1	1072.9	1072.9	1072.6	1072.8	1074.5	1072.5	1073.6	1072.1

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 128.

[2] *Loc. cit.*

oratories to assume that constant weight has been reached if the specimen is kept three, sometimes even as low as two, days at the temperature specified.

Cold Immersion.—An open water bath without temperature control was used for the cold immersion tests. The temperatures were within the limits of 15.5 to 30 C. prescribed by the 1935 tentative methods.[1] A precaution to be observed for certain types of bricks with very high rates of absorption is immediately to immerse the brick specimens completely. It has been observed[2] that preliminary partial immersion followed by total immersion gives slightly higher results at 24 hr. than does immediate total immersion. Weighings after cold immersion were completed within 45 min.

Five-Hour Boiling Test.—With the exception of test No. 7, all 5-hr. boiling absorption tests were made in a boiler equipped with a lid, a drain, and an overflow pipe. The burners were not lighted until all the half bricks were in place and completely immersed. The specimens were separated by spacers so that free circulation of water was possible on all sides. Vigorous boiling was attained within 45 min. During boiling, water was added continuously to maintain complete immersion without interrupting the boiling. In tests Nos. 1, 4, and 8, the heater was shut off after 5 hr. boiling, the lid removed, and the contents permitted to cool over night. In cooling for tests Nos. 2 and 9 the drain pipe was opened and a stream of water from a tap directed into the tank at such a rate that water ran from the overflow. At the end of 1 hr., the drain pipe and tap were closed and weighing was started immediately. In test No. 3 the tank was half full of water at the end of the boiling period (with all of the specimens totally immersed however), then it was quickly filled with cold tap water, and the contents were allowed to cool by natural heat loss for 1 hr. before weighing. In test No. 5 the contents of the tank were allowed to cool

TABLE IV.—GAIN IN WEIGHT OF NON-DEAIRED HALF BRICKS AFTER 24 AND 48-HR. IMMERSION IN COLD WATER.

Specimen	Gain in Weight, per cent of dry weight										Weight for 0.1 per cent, g.[a]
	Absorption After 24 hr.					Absorption After 48 hr.					
	Test No. 1	Test No. 7	Test No. 8	Test No. 9	Average	Test No. 1	Test No. 7	Test No. 8	Test No. 9	Average	
No. 1	25.73	25.82	26.17	25.59	25.83	26.19	26.45	26.74	26.75	26.53	0.87
No. 2	22.04	22.35	22.28	22.40	22.27	22.36	22.61	22.65	22.61	22.56	0.95
No. 3	15.18	15.22	15.22	15.29	15.23	15.31	15.48	15.41	15.42	15.40	0.80
No. 4	15.24	15.09	15.27	15.27	15.22	15.41	15.37	15.48	15.43	15.41	0.93
No. 5	15.99	16.18	16.18	16.12	16.12	16.33	16.52	16.58	16.47	16.48	0.88
No. 6	13.95	14.42	14.39	14.54	14.32	14.10	14.66	14.66	14.73	14.54	1.09
No. 7	12.27	12.61	12.61	12.67	12.54	12.37	12.85	12.91	12.76	12.72	1.04
No. 8	12.32	12.46	12.39	12.49	12.42	12.47	12.61	12.65	12.71	12.61	1.33
No. 9	8.06	8.06	8.06	8.11	8.07	8.39	8.40	8.40	8.45	8.41	1.04
No. 10	7.99	8.19	8.26	8.20	8.16	8.17	8.43	8.38	8.38	8.34	0.83
No. 11	4.66	4.66	4.65	4.74	4.68	4.75	4.80	4.85	4.85	4.81	1.04
No. 12	3.89	4.00	4.06	4.00	3.99	3.94	4.21	4.22	4.16	4.13	0.95
No. 13	2.81	2.75	2.75	2.81	2.78	2.97	2.92	2.97	2.92	2.34	0.91
No. 14	0.64	0.60	0.55	0.64	0.61	0.72	0.72	0.64	0.72	0.70	1.25
No. 15	0.29	0.29	0.17	0.25	0.25	0.29	0.34	0.21	0.25	0.27	1.19
No. 16	0.88	0.76	0.68	0.76	0.77	0.93	0.90	0.80	0.92	0.89	1.24
No. 17	1.18	1.43	1.43	1.48	1.38	1.33	1.53	1.53	1.58	1.49	1.01
No. 18	1.02	0.85	0.86	0.94	0.92	1.05	0.94	0 94	0.99	0.98	1.81
No. 19	0.40	0.29	0.22	0.29	0.30	0.57	0.36	0.25	0.29	0.37	1.39
No. 20	0.09	0.14	0.14	0.18	0.14	0.14	0.18	0.14	0.18	0.16	1.10
No. 21	0.35	0.35	0.28	0.42	0.35	0.35	0.42	0.28	0.42	0.37	0.70
No. 22	0.08	0.08	0.08	0.08	0.08	0.12	0.12	0.12	0.08	0.11	1.25

[a] Grams change in weight for 0.1 per cent change in absorption.

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[1] *Loc. cit.*

[2] J. W. McBurney, "The Water Absorption and Penetrability of Brick," *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part II, p. 714 (1929).

naturally for 1 hr. before weighings were started. Test No. 6 consisted in removing the specimens from the continuously boiling water and weighing after 4 min. suspension in air. At the end of 4 min. no free water was visible on the surfaces of the specimens. In test No. 7 the water was not brought to boiling, in order to demonstrate the effect of failure to meet this requirement.

A different order of handling and weighing specimens was used for each test. In general the first specimen immersed was the first removed.

Discussion of Data on Non-Deaired Bricks:

Tables III to VI, inclusive, present the data on the 22 non-deaired bricks described in Table I. The specimens are numbered from 1 to 22 in order of decreasing water absorption in the 5-hr. boiling test.

TABLE V.—GAIN IN WEIGHT OF NON-DEAIRED HALF BRICKS AFTER 5-HR. BOILING USING VARIOUS METHODS OF TEST.

Specimen	Gain in Weight, per cent of dry weight								
	Test No. 1	Test No. 2	Test No. 3	Test No. 4	Test No. 5	Test No. 6	Test No. 7	Test No. 8	Test No. 9
No. 1	31.16	31.57	30.05	31.06	29.78	23.18	30.18	31.46	31.34
No. 2	26.33	26.31	25.26	26.17	24.76	18.93	25.60	26.43	26.39
No. 3	18.91	19.01	18.39	18.76	17.58	13.53	18.59	18.70	18.98
No. 4	18.25	18.21	17.40	18.11	17.08	12.84	17.14	18.28	18.01
No. 5	18.14	17.93	17.59	18.05	17.09	14.53	18.23	18.11	18.23
No. 6	16.77	17.20	17.03	17.03	16.53	14.52	17.15	17.25	17.48
No. 7	15.53	15.79	15.57	15.67	15.29	12.15	15.74	15.88	16.04
No. 8	14.38	14.45	14.11	14.34	13.74	10.98	14.23	14.53	14.67
No. 9	12.15	12.07	11.82	11.97	11.53	9.22	11.68	12.16	12.21
No. 10	9.99	10.13	9.76	10.07	9.46	7.04	10.07	10.26	10.33
No. 11	8.16	8.21	7.77	8.21	7.53	4.22	7.73	8.16	8.26
No. 12	6.42	6.53	6.27	6.69	6.16	3.42	6.32	6.59	6.58
No. 13	3.58	3.08	3.19	4.18	2.26	0.93	3.19	3.58	3.30
No. 14	2.72	2.72	2.64	2.92	2.64	0.32	2.44	2.07	2.60
No. 15	2.40	1.05	1.39	3.12	1.27	0.09	1.64	0.92	0.72
No. 16	2.81	2.89	2.89	3.22	2.65	0.80	2.49	2.24	2.25
No. 17	1.73	1.28	2.27	3.21	2.57	0.39	1.97	2.22	2.22
No. 18	2.35	2.87	2.87	3.18	2.46	0.83	2.21	2.49	2.40
No. 19	2.27	1.44	1.69	3.13	1.40	0.14	1.69	1.22	0.94
No. 20	0.36	0.32	0.23	0.27	0.18	0.09	0.27	0.27	0.36
No. 21	0.64	0.56	0.50	0.49	0.28	0.28	0.42	0.49	0.49
No. 22	0.24	0.24	0.24	0.28	0.08	0.08	0.20	0.20	0.24
Average, Nos. 1 to 11	17.25	17.35	16.79	17.22	16.40	12.83	16.99	17.40	17.45
Average, Nos. 12 to 22	2.33	2.09	2.20	2.79	2.00	0.69	2.08	2.03	2.01
Average, all specimens	9.79	9.71	9.50	10.01	9.20	6.75	9.53	9.71	9.73

Drying.—The progressive loss in weight during the tests that characterizes specimens Nos. 1, 6, 7 and 8 appears to have been caused by abrasive wear of these rather soft bricks. This fact should be taken into account in interpreting the data.

The slightly higher and somewhat variable results on the dry weights of test No. 1 compared with the dry weights of succeeding tests may be explained by dirt present in the pores of the bricks. It can be assumed that this dirt was removed by boiling.

It is concluded that 3 days drying at 105 C. can be expected to dry satisfactorily non-deaired bricks showing over 8 per cent absorption (based on dry weight) after 5 hr. boiling. As a matter of added safety, it is considered advisable to increase this period to 4 days. For less-absorptive bricks such a treatment may or may not be satisfactory.

Absorption by 5-hr. Boiling.—Table V, giving gains in weight after 5-hr. boiling, provides a basis for the following conclusions: (1) If the 5-hr.-boiling test is made on non-deaired bricks of moderate to high absorption (above 8.0 per cent by 5-hr. boiling) which have been previously soaked in cold water for 48 hr., the total absorptions thus measured exhibit, in general, slightly higher absorptions than result from the 5-hr.-boiling test made on the same bricks not previously soaked (compare tests Nos. 4 and 8). (2) The differences found by comparing forced cooling with overnight cooling for the high and moderate absorption bricks, comparing test No. 2 with test No. 4 and test No. 8 with test No. 9, are of the order of the difference between duplicate tests Nos. 1 and 8, approximately 0.1 to 0.2 per cent. The forced cooling usually gives very slightly higher results in both comparisons. This may be due to the forced cooling having reached a temperature approximately 10 deg. Cent. lower than that of the overnight cooling. (3) The higher the temperature of the bath at the time the specimen is removed and weighed, the lower the apparent absorption. Comparing tests Nos. 3, 5 and 6, only one specimen (No. 17) is exceptional. In the case of one other low absorption brick (No. 14) tests Nos. 3 and 5 give the same value. For the two least-absorbent specimens (Nos. 21 and 22) tests Nos. 5 and 6 show no difference.

TABLE VI.—RATIOS OF ABSORPTION BY COLD IMMERSION TO ABSORPTION AFTER BOILING OF NON-DEAIRED HALF BRICKS.

Specimen	Ratio, 24-hr. Cold Absorption to Absorption After 5-hr. Boiling					Ratio, 48-hr. Cold Absorption to Absorption After 5-hr. Boiling				
	1/1[a]	7/2[a]	7/4[a]	8/8[a]	9/9[a]	1/1[a]	7/2[a]	7/4[a]	8/8[a]	9/9[a]
No. 1	0.822	0.818	0.831	0.832	0.835	0.841	0.838	0.852	0.850	0.853
No. 2	0.837	0.849	0.854	0.843	0.849	0.849	0.859	0.864	0.857	0.857
No. 3	0.803	0.801	0.811	0.805	0.806	0.810	0.814	0.824	0.815	0.812
No. 4	0.835	0.828	0.833	0.835	0.848	0.844	0.844	0.849	0.847	0.857
No. 5	0.881	0.903	0.896	0.893	0.885	0.900	0.921	0.915	0.915	0.903
No. 6	0.832	0.804	0.847	0.834	0.835	0.841	0.852	0.861	0.850	0.846
No. 7	0.790	0.798	0.805	0.794	0.790	0.797	0.814	0.820	0.813	0.796
No. 8	0.857	0.862	0.868	0.853	0.851	0.867	0.872	0.879	0.871	0.866
No. 9	0.663	0.668	0.673	0.663	0.664	0.690	0.696	0.702	0.691	0.692
No. 10	0.800	0.808	0.813	0.805	0.794	0.818	0.832	0.837	0.817	0.812
No. 11	0.571	0.568	0.566	0.571	0.570	0.582	0.585	0.585	0.594	0.587
No. 12	0.606	0.612	0.598	0.601	0.608	0.614	0.645	0.629	0.640	0.632
No. 13	0.785	0.893	0.658	0.768	0.850	0.829	0.948	0.699	0.829	0.883
No. 14	0.235	0.221	0.205	0.202	0.246	0.265	0.261	0.247	0.309	0.277
No. 15	0.121	0.276	0.093	0.185	0.353	0.121	0.324	0.109	0.228	0.353
No. 16	0.313	0.263	0.236	0.304	0.350	0.331	0.312	0.280	0.353	0.411
No. 17	0.682	1.118	0.445	0.644	0.667	0.769	1.195	0.477	0.689	0.711
No. 18	0.434	0.296	0.267	0.345	0.391	0.447	0.328	0.296	0.377	0.414
No. 19	0.176	0.202	0.093	0.180	0.308	0.251	0.250	0.115	0.205	0.308
No. 20	0.250	0.438	0.519	0.519	0.500	0.389	0.563	0.667	0.519	0.500
No. 21	0.547	0.625	0.714	0.572	0.857	0.547	0.750	0.857	0.572	0.857
No. 22	0.333	0.333	0.286	0.400	0.333	0.500	0.500	0.429	0.600	0.333

[a] The numerator is the test number in Table IV and the denominator is the test number in Table V.

Absorption Ratios.—From Table VI it is seen that, with the exception of specimens Nos. 5 and 6, ±0.01 covers the range of ratios of absorption after 24-hr. cold immersion to absorption after 5-hr. boiling for specimens Nos. 1 to 11, inclusive. The variability is greater for the lower absorptions associated with low ratios.

A comparison of the ratios calculated for 24 and 48-hr. cold immersions shows that the 24-hr. ratios are lower on the average by 0.017 for specimens Nos. 1 to 11, inclusive, and by 0.045 for specimens Nos. 12 to 22, inclusive.

DEAIRED BRICK

Description of Test Specimens:

Specimens Nos. 23, 24 and 25 represent "dark," "medium" and "light" deaired paving brick from Ohio. They were side cut shale with flat compressive strengths of 16,000, 13,350 and 16,350 lb. per sq. in. respectively. Specimens Nos. 23 and 24 appeared to be completely vitrified.

Some weeks after starting absorption tests on specimens Nos. 1 to 25, fifteen specimens of a deaired, side-cut shale brick ranging from dark to light in color were received from Iowa. These bricks were broken transversely, one set of halves marked "*A*" and the other "*B*." Tests were made on both sets simultaneously. Data on only 5 of these 15 specimens are given in Tables VIII to XI because these data cover the range of all the specimens. Since definite proof was lacking that the two halves of each brick were strictly comparable, the results on set *A* are distinguished from the results on set *B*. These bricks were fine grained and notably die laminated. The flat compressive strengths were 20,120, 13,620, 11,270, 11,950 and 11,900 lb. per sq. in. for specimens Nos. 26 to 30, respectively.

TABLE VII.—VARIABLES USED IN DETERMINING ABSORPTION BY 5-HR. BOILING OF DEAIRED BRICK.[a]

	Test No. 1	Test No. 2A	Test No. 2	Test No. 4	Test No. 7A	Test No. 7B	Test No. 9A	Test No. 9
Drying of specimens	See footnotes for Table VIII							
Treatment of half bricks previous to boiling	48-hr. cold immersion	none	none	none	none	24-hr. cold immersion	48-hr. cold immersion	48-hr. cold immersion
Time elapsed between completion of boiling and start of weighing	18 hr.	1 hr., 30 min.	2 hr.	18 hr.	13 hr., 15 min.[b]	13 hr., 15 min.[b]	1 hr., 30 min.	2 hr.
Time required for completion of weighing, min.	30	30	30	30	30	30	30	30
Temperature of water at time of start of weighing, deg. Cent.	30	12.25	12.5	30	26	26	12.25	12.5
Temperature of water at time of completion of weighing, deg. Cent.	29	12.5	13	29	25.5	25.5	12.5	13

[a] This table applies to specimens Nos. 26 to 30 only; specimens Nos. 23, 24 and 25 were tested as described in Table II.

[b] The maximum temperature of the water was 94 C.; it was reached $5\frac{1}{2}$ hr. after starting heating. This temperature was maintained for 5 hr. and the heat was then shut off and cooling occurred during the time indicated.

TABLE VIII.—WEIGHTS IN GRAMS TO NEAREST $\frac{1}{2}$ G. OF DEAIRED HALF BRICK SPECIMENS AFTER DRYING.

Specimen	Test No. 1	Test No. 2	Test No. 3	Test No. 4	Test No. 5	Test No. 6	Test No. 7	Test No. 8	Test No. 9
No. 23[a]	1749.5	1749.5	1749.0	1750.0	1749.5	1750.5	1749.5	1749.5	1749.5
No. 24[a]	1980.5	1977.0	1976.5	1977.0	1981.0	1979.0	1978.0	1978.5	1973.5
No. 25[a]	1981.5	1981.0	1982.0	1982.0	1982.5	1982.5	1982.5	1983.5	1982.0
	Test No. 1[c]	Test No. 2A[d]	Test No. 2[f]	Test No. 4[c]	Test No. 7A[e]	Test No. 7B[e]	Test No. 9A[d]	Test No. 9[f]	
No. 26A[b]	931.5	955.0	935.5	.....	932.5	.....	.....	.....	
No. 26B[b]	.....	.....	.....	947.0	.....	948.0	997.0	949.0	
No. 27A[b]	993.5	1006.5	994.5	.....	994.0	.....	.....	.....	
No. 27B[b]	.....	.....	.....	963.0	.....	964.0	999.0	964.5	
No. 28A[b]	942.5	944.0	944.0	.....	944.5	.....	.....	.....	
No. 28B[b]	.....	.....	.....	932.0	.....	931.0	933.5	933.5	
No. 29A[b]	967.5	968.0	968.0	.....	968.0	.....	.....	.....	
No. 29B[b]	.....	.....	.....	953.5	.....	954.0	964.5	954.5	
No. 30A[b]	937.5	937.5	938.0	.....	937.5	.....	.....	.....	
No. 30B[b]	.....	.....	.....	966.0	.....	966.0	966.5	966.5	

[a] Specimens Nos. 23, 24 and 25 were dried at the same time and under the same conditions as Specimen Nos. 1 to 22 listed in Table I. See Table II.

[b] A and B are halves of the same brick.

[c] Specimens Nos. 26 to 30, inclusive, were dried simultaneously and under like conditions in tests Nos. 1 and 4. The procedure consisted in taking the bricks as received (presumably kiln dry) and leaving them in the oven 72 hr. at 102 to 105 C.

[d] Specimens Nos. 26 to 30 inclusive, were dried simultaneously and under like conditions in tests Nos. 2A and 9A. The procedure consisted of drying the specimens in the oven for 72 hr. at 102 to 105 C. after completion of tests Nos. 1 and 4.

[e] Specimens Nos. 26 to 30 inclusive, were dried simultaneously and under like conditions in tests Nos. 7A and 7B. The procedure consisted of drying the specimens in the oven for 120 hr. at 110 to 115 C. after completion of tests Nos. 2A and 9A.

[f] Specimens Nos. 26 to 30, inclusive, were dried simultaneously and under like conditions in tests Nos. 2 and 9. The procedure consisted of drying the specimens in the oven for 168 hr. at 115 to 124 C. after completion of tests Nos. 7A and 7B.

Methods of Test:

Specimens Nos. 23 to 25 were tested at the same time and in the same manner as non-deaired specimens Nos. 1 to 22. The methods are therefore the same as described in Table II. Table VII gives the methods of testing specimens Nos. 26 to 30. The test procedures in tests Nos. 1, 2, 4, and 9, the results of which are listed in this table, are essentially the same as those for the correspondingly numbered tests in Table II. Tests Nos. 2A, 7A, and 9A represent modifications of tests Nos. 2, 7, and 9, respectively.

Discussion of Data on Deaired Bricks:

Drying.—Specimens Nos. 23, 24, and 25 dried satisfactorily in 4 days at 102 to 105 C. Three days' drying at 102 to 105 C. left 50 g. excess weight in specimen No. 26B compared with the original dry weight (compare test No. 4 with No. 9A in Table VIII). Five days at 110 to 115 C. (test No. 7B) were required to check to 1.0 g. the weight of this specimen after the preliminary drying of test No. 4. For specimens Nos. 26 to 30, the drying behavior can be summarized by the following statements: (1) The higher the water absorption the more quickly the brick dries. (2) Abnormal retention of water is associated with large differences in the absorption of water under different experimental procedures.

TABLE IX.—GAIN IN WEIGHT OF DEAIRED HALF BRICKS AFTER 24 AND 48-HR. IMMERSION IN COLD WATER.

Specimen	Gain in Weight, per cent of dry weight							
	Absorption After 24 hr.				Absorption After 48 hr.			
	Test No. 1	Test No. 7	Test No. 8	Test No. 9	Test No. 1	Test No. 7	Test No. 8	Test No. 9
No. 23	0.11	0.14	0.17	0.14	0.20	0.20	0.17	0.20
No. 24	0.15	0.18	0.15	0.20	0.23	0.23	0.18	0.25
No. 25	2.40	2.24	2.19	2.27	2.45	2.37	2.34	2.40
	Test No. 1	Test No. 7B	Test No. 9A[a]	Test No. 9	Test No. 1	Test No. 7B	Test No. 9A[a]	Test No. 9
No. 26A	3.17	.....	.....	.....	4.72	Not Determined	.....	.....
No. 26B	.....	2.64	7.97	3.27	.....		8.03	4.32
No. 27A	7.25	.....	.....	.....	8.25		.....	.....
No. 27B	.....	6.64	9.04	6.74	.....		9.14	7.78
No. 28A	10.18	.....	.....	.....	10.34		.....	.....
No. 28B	.....	9.67	9.76	9.43	.....		9.93	9.53
No. 29A	9.41	.....	.....	.....	9.46		.....	.....
No. 29B	.....	9.33	9.44	9.32	.....		9.60	9.43
No. 30A	12.11	.....	.....	.....	12.23		.....	.....
No. 30B	.....	12.06	12.22	12.05	.....		12.47	12.26

[a] Test No. 9A is here calculated from the dry weights determined in test No. 4 (Table VIII).

Cold Absorption.—From Table IX (percentage gain in weight of deaired bricks after 24 and 48-hr. cold immersion), it appears that the results for specimens Nos. 23 to 25 are as consistent as would be expected for bricks having such low absorptions. Specimens Nos. 26 and 27, the two "hardest burned" of the series, Nos. 26 to 30, give unsatisfactory checks. Absorption values for the two relatively "medium burned" specimens (Nos. 29 and 30) compare favorably from the standpoint of reproducibility with the values reported in Table IV. Specimens Nos. 26 and 27 show unusually large differences between the results for 24 and 48-hr. cold immersion. Test No. 9A represents absorption determined upon partially dried specimens and calculated on the bases of dry weights of test No. 4.

Absorption by 5-hr. Boiling.—The data on specimens Nos. 26 to 30 (Table X) warrant the following conclusions: (1) The absorption by 5-hr. boiling is much higher when conducted on dry, "hard burned" specimens than when conducted on specimens previously immersed for 48 hr. in cold water. Compare tests No. 1 with No. 4 and No. 9 with No. 2 for specimens Nos. 26 and 27. (2) Relatively underburned specimens (Nos. 29 and 30) reverse this relation. Applying the absorption test by 5-hr. boiling to bricks previously subjected to the 48-hr. cold immersion test gives slightly higher results than when the same bricks are boiled without previous cold immersion. Compare tests No. 1 with No. 4 and No. 2 with No. 9 for specimens Nos. 29 and 30. (3) With one exception (specimen No. 28) all specimens cooled overnight have slightly higher absorptions than are given by specimens subjected to forced cooling, other things being equal. Compare tests No. 1 with No. 9 and No. 2 with No. 4. (4) Failure to boil (tests Nos. 7A and 7B) gives somewhat lower results than the other methods where allowance is made for the previous treatment of the specimens (either dry or soaked cold).

TABLE X.—GAIN IN WEIGHT OF DEAIRED HALF BRICKS AFTER 5-HR. BOILING USING VARIOUS METHODS OF TEST DESCRIBED IN TABLES II, VII, AND VIII.

Specimen	Gain in Weight, per cent of dry weight								
	Test No. 1[a]	Test No. 2[a]	Test No. 3[a]	Test No. 4[a]	Test No. 5[a]	Test No. 6[a]	Test No. 7[a]	Test No. 8[a]	Test No. 9[a]
No. 23	0.25	0.17	0.10	0.26	0.06	0.00	0.23	0.25	0.26
No. 24	0.35	0.30	0.43	1.63	0.10	0.05	0.30	0.35	0.33
No. 25	4.11	5.15	4.84	5.05	4.31	2.30	4.36	4.56	4.62
	Test No. 1[b]	Test No. 2A[b], [c]	Test No. 2[b]	Test No. 4[b]	Test No. 7A[b]	Test No. 7B[b]	Test No. 9A[b], [d]	Test No. 9[b]	
No. 26A	7.19	6.33	5.30	.....	9.76	.....	.....	.....	
No. 26B	.....	.....	.....	10.77	.....	7.54	7.39	4.32	
No. 27A	9.21	9.55	12.02	.....	11.47	.....	.....	.....	
No. 27B	.....	.....	.....	12.41	.....	8.45	9.55	8.19	
No. 28A	12.63	15.44	14.62	.....	13.28	.....	.....	.....	
No. 28B	.....	.....	.....	12.63	.....	11.85	12.88	12.85	
No. 29A	10.85	11.73	10.79	.....	10.38	.....	.....	.....	
No. 29B	.....	.....	.....	11.04	.....	10.01	10.80	10.69	
No. 30A	14.03	13.33	13.27	.....	14.19	.....	.....	.....	
No. 30B	.....	.....	.....	13.46	.....	13.15	13.98	13.92	

[a] See Table II for description of methods of test.
[b] See Table VIII for description of methods of test.
[c] Calculated using dry weights of test No. 1.
[d] Calculated using dry weights of test No. 4.

Absorption Ratios.—The C/B ratios have little utility for specimens of lowest absorption such as specimens Nos. 23 and 24 (Table XI). The values for the ratios of specimens Nos. 26 and 27 vary widely but with the exception of the ratios based upon test No. 9A (incomplete drying) and test No. 9 (specimen No. 27 only) the C_{24}/B_5 ratios are all under 0.80. Specimen No. 28 is above 0.80 for test No. 1 and below 0.80 for the other C_{24}/B_5 combinations. Specimens Nos. 29 and 30 are in fair agreement for all combinations of tests.

SPECIFICATIONS AND METHODS OF TESTING

There has been proposed a modification of the Tentative Specifications for Building Brick (Made from Clay or Shale) (C 62 – 35 T)[1] which provides the following requirements for the highest grade of weathering resistance: A flat compressive strength of not less than 2500 lb. per sq. in., a water absorption by 5-hr. boiling of not to exceed 20.0 per cent and a C_{24}/B_5 ratio (ratio of absorption by 24-hr. cold immersion to absorption by 5-hr. boiling) of not more than 0.80. The following paragraph is quoted from this revision: "2 (*c*) If the average compressive strength is greater than 8000 lb. per sq. in. *or* the average water absorption is less than 8.0 per cent by weight after 5-hr. boiling, the requirement for C/B shall be waived." It would appear reasonable to add to the above paragraph another clause as follows: "*or* the average water absorption is less than 6.4 per cent by 24-hr. cold immersion."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 788 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 458.

It follows, therefore, that since Section 2 (*c*) classifies in the highest grade all bricks with flat compressive strength above 8000 lb. per sq. in. *or* with 5-hr. boiling water absorption under 8.0 per cent, only the first eleven specimens in Table I need be considered from the standpoint of reproducible determinations of C/B ratios. Of these eleven specimens, specimens Nos. 5, 10, and 11 would be classified as belonging to the highest grade of weather resistance on account of their flat compressive strength which is in excess of 8000 lb. per sq. in. Specimens Nos. 26 to 30 all exceed 8000 lb. per sq. in. and so are excepted from the use of the C/B ratio in classification.

TABLE XI.—RATIOS OF ABSORPTION BY COLD IMMERSION TO ABSORPTION AFTER BOILING OF DEAIRED HALF BRICKS.

Specimen	Ratio, 24-hr. Cold Absorption to Absorption After 5-hr. Boiling					Ratio, 48-hr. Cold Absorption to Absorption After 5-hr. Boiling				
	1/1[a]	7/2[a]	7/4[a]	8/8[a]	9/9[a]	1/1[a]	7/2[a]	7/4[a]	8/8[a]	9/9[a]
No. 23	0.440	0.823	0.539	0.680	0.555	0.800	1.176	0.769	0.680	0.778
No. 24	0.429	0.600	0.110	0.429	0.615	0.657	0.657	0.141	0.514	0.769
No. 25	0.584	0.435	0.444	0.480	0.492	0.596	0.460	0.469	0.511	0.519
	1/1[a]	1/2[a]	9/4[a]	9A/9A[a]	9/9[a]	1/1[a]	1/2[a]	9/4[a]	9A/9A[a]	9/9[a]
No. 26A	0.441	0.598	.....	.....	.....	0.655	0.891	.....	.....	.....
No. 26B	.....	.....	0.304	1.079	0.757	.....	.....	0.401	1.087	1.000
No. 27A	0.787	0.603	.....	.....	.....	0.896	0.759	.....	.....	.....
No. 27B	.....	.....	0.543	0.947	0.822	.....	.....	0.603	0.957	0.949
No. 28A	0.807	0.696	.....	.....	.....	0.819	0.707	.....	.....	.....
No. 28B	.....	.....	0.746	0.758	0.734	.....	.....	0.755	0.771	0.742
No. 29A	0.867	0.872	.....	.....	.....	0.870	0.877	.....	.....	.....
No. 29B	.....	.....	0.844	0.874	0.872	.....	.....	0.854	0.889	0.882
No. 30A	0.863	0.913	.....	.....	.....	0.872	0.922	.....	.....	.....
No. 30B	.....	.....	0.895	0.874	0.866	.....	.....	0.911	0.892	0.881

[a] The numerator is the test number in Table X.
The denominator is the test number in Table XI.

Since it has been shown that the water absorption of bricks showing an absorption over 8 per cent by 5-hr. boiling can be determined satisfactorily by certain of the methods herein described, there remains only the matter of suggesting certain modifications in the sections of the 1935 Tentative Methods of Testing Brick (Modulus of Rupture, Compressive Strength, Absorption) (C 67 – 35 T)[1] dealing with absorption. The numbering of the sections refers to these methods.

Section 16 (*a*).—Insert "in a ventilated oven" after "weight" in the first line. Change "100 to 105 C. (212 to 221 F.)" to "110 to 115 C. (230 to 239 F.)." Add "NOTE.—It can be assumed that heating for 72 hr. at these temperatures will assure constant weight except for deaired bricks or bricks whose absorption is less than 8.0 per cent by 5-hr. boiling as determined under Section 20 (*c*)."

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[1] *Proceedings,* Am. Soc. Testing Mats., Vol. 35, Part I, p. 791 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 461.

Section 16 (*c*).—Insert the word "immediately" before "submerged" in the first line. Insert "without preliminary partial immersion" after "submerged" in the first line. Strike out "quickly" before "weighed" in the last line and add the sentence, "Weighing of any one specimen shall be completed within 5 min. after removing the specimen from the bath."

Section 20 (*a*).—Strike out the first sentence. Change the second sentence to read, "The specimen which has been saturated 24 hr. in the cold-water immersion bath shall be returned to the bath and subjected to a 5-hr. boiling test as described in Paragraph (*c*)."

Section 20 (*c*).—Add after the first sentence "in such a manner that water can circulate freely on all sides of the specimen." Add to the second sentence "by natural loss of heat for not less than 16 nor more than 18 hr." Strike out "quickly" in the last line and add the sentence, "Weighing of any one specimen shall be completed within 5 min. after removing the specimen from the bath." Add the following: "NOTE.—If the tank is equipped with a drain so that water at a temperature of 15.5 to 30 C. (60 to 86 F.) can be passed through the tank continuously and at such a rate that a complete change of water takes place in not more than 2 min., weighings can be made at the end of 1 hr.

Add a new section after Section 21 to read as follows:

22. *Absorption Ratio.*—The C/B ratio of each specimen shall be calculated by the use of the following formula:

$$\text{Absorption ratio (C/B)} = \frac{b - a}{B - a}$$

where a = the dry weight of the specimen,
b = the saturated weight of the specimen after 24-hr. cold submergence, and
B = the saturated weight of the specimen after 5-hr. boiling.

SUMMARY AND CONCLUSIONS

This paper describes several methods of determining water absorptivity of building brick by 5-hr. boiling methods and records the results obtained by using these methods on 30 brick specimens including both deaired and non-deaired bricks.

From the data here presented, the following conclusions are considered justified:

1. Drying for 72 hr. at a temperature of 110 to 115 C. in a ventilated oven is sufficient to bring non-deaired brick of moderate to high water absorption (above 8.0 per cent by the 5-hr. boiling test) to dry weight constant to ±0.5 g.

2. Certain less absorptive bricks and certain deaired bricks are not dried satisfactorily by the above treatment and exposure to a temperature of 110 to 115 C. for five days is required.

3. If the 5-hr. boiling test is made on non-deaired bricks of moderate to high absorption above 8.0 per cent by 5-hr. boiling) which have been previously immersed in cold water for 48 hr., the total absorption thus measured is, in general, slightly higher than if the 5-hr. boiling test is made on the same bricks not previously immersed.

4. Certain "hard-burned" deaired bricks do not conform in their behavior to conclusion 3. The 5-hr. boiling test gives much higher absorptions when used on dry bricks of this type than on the same bricks previously immersed cold. The "medium burned" bricks of the same brand conform to conclusion 3 in their behavior.

5. For non-deaired bricks of moderate to high absorption (above 8.0 per cent by the 5-hr. boiling test), the difference between the results of 5-hr. boiling followed by thorough forced cooling in 1 hr. and the same test followed by 16 hr. slow cooling is negligible.

6. The higher the temperature of the bath at the time the brick specimen is removed for weighing, the lower the weight of absorbed water.

7. Failure to reach boiling temperature in the bath lowers the amount of water absorbed.

8. The use of incompletely dried test specimens results in error, unpredictable in size and direction, depending apparently upon the nature of the brick.

9. Confining consideration to methods believed to conform to a reasonable interpretation of the 1935 Tentative Methods of Testing Brick (Modulus of Rupture, Compressive Strength, Absorption) (C 67 – 35 T),[1] the 5-hr. boiling test for absorption on sound bricks of moderate to high absorption (above 8.0 per cent by 5-hr. boiling) is, in general, reproducible to within ±0.15 per cent.

10. For bricks of moderate to high absorption (above 8.0 per cent by 5-hr. boiling) the difference between the C_{24}/B_5 and C_{48}/B_5 ratios (ratios of absorption during cold immersion to absorption by 5-hr. boiling) is small.

Acknowledgments:

The help of Mr. A. R. Eberle in the laboratory is acknowledged. Mr. J. C. Everds of Iowa State College called attention to the peculiar behavior of bricks represented by samples Nos. 26 to 30.

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[1] *Loc. cit.*

DISCUSSION

Mr. R. B. Keplinger[1] (*presented in written form*).—Mr. McBurney's paper on "Water Absorption of Building Brick" is complete, comprehensive and certainly irrefutable from the manufacturers' perspective and his proposals are believed to protect fairly and satisfactorily the interests of both consumer and manufacturer. To the knowledge of the writer it is the first practicable and presumably acceptable attempt to define and specify the requirements of a building brick for facing purposes.

We wish to suggest that there is some evidence that a factor of correction or a tolerance may be justified in the C/B ratio for cored brick, based possibly on the additional exposed areas or surfaces incidental to the coring. It also may be argued that some allowance be made in transverse and compression requirements for cored brick. If, however, the proposed modification of the Tentative Specifications for Building Brick (C 62 – 35 T) be accepted, providing for the highest grade of weathering resistance, a flat compressive strength of not less than 2500 lb. per sq. in., water absorption by 5 hr. boiling of not to exceed 20 per cent and a C_{24}/B_5 ratio of not more than 0.80, it would hardly seem either necessary or advisable to lower the minimum compressive strength requirement further.

Results of absorption, compression, flexure, scleroscope, and C/B tests made by Mr. J. O. Everhart of the Engineering Experiment Station, Ohio State University, on brick samples from six Ohio and Pennsylvania building brick manufacturers, representing five different shales and one coal measure fire clay are presented in the accompanying Table I. These samples were selected to represent both the hard fired and the soft fired product of each manufacturer in order to cover the commercial range.

It may be noted that the only two sets of samples exceeding the C_{24}/B_5 ratio of 0.80, either soft or hard fired, were Nos. 1 and 5, both of which were cored. It may also be noted that the absorption results on No. 5 hard shale were low and the compressive and flexural strengths high, whereas the C_{24}/B_5 ratio was 0.834. In the case of both of these sets of samples the requirements for C/B ratio would be waived by reason of high compressive strength or low absorption; but it is also possible that the coring may have introduced another variable. These results, of course, tie in with some of the variable results found by Mr. McBurney on hard-burned de-aired brick of low absorption, but as the results of the other four groups of samples were quite consistent and as they represented also hard-burned, high-strength and in at least one instance, de-aired brick, there is some indication that the coring may have affected the C/B ratio. We should like very much to see Mr. McBurney include in his further investigation some representative samples of cored brick.

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[1] Vice-President, Metropolitan Paving Brick Co., Canton, Ohio.

Mr. Everhart ran the above tests to check the absorption specifications of the Housing Division of P. W. A. requiring, originally, a minimum rate of absorption of not less than 1 oz. on the average, with brick immersed in water flat, to a depth of $\frac{1}{8}$ in., for a period of 3 min. We understand this has been revised to $\frac{1}{2}$ oz. average in 3 min. with an individual minimum of 0.15 oz. Even with this modification, none of the hard-fired brick of these six representative manufacturers will meet this specification and it is believed that the bulk of the medium-burned product would also be excluded.

TABLE I.—RESULTS OF TESTS BY J. O. EVERHART, OHIO STATE UNIVERSITY EXPERIMENT STATION.

Manufacturer	Grade	Absorption in 3 min., oz.,	Absorption in 10 min., oz.	Absorption in 5-hr. soak, per cent	Absorption in 5-hr. boil, per cent	Absorption in 24-hr. soak, per cent	Absorption in 48-hr. soak, per cent	Compressive Strength, lb. per sq. in.	Flexural Strength, lb. per sq. in.	Scleroscope Hardness	C_{24}/B_5 Ratio	C_{48}/B_5 Ratio
No. 1[a]...............	Hard fire clay	0.12	0.17	2.16	3.99	2.32	2.61	17 758	1 486	68	0.581	0.654
	Soft fire clay	0.86	1.56	5.80	7.79	6.26	6.40	8 989	907	47	0.804	0.822
No. 2...............	Hard shale	0.36	0.42	2.14	6.35	3.12	3.27	18 914	2 716	78	0.491	0.515
	Soft shale	1.42	2.47	7.19	9.47	7.49	7.75	12 689	1 951	55	0.791	0.818
No. 3...............	Hard shale	0.045	0.064	0.70	2.18	0.85	0.98	19 226	3 385	96	0.289	0.449
	Soft shale	2.13	4.09	7.82	10.23	8.08	9.00	12 278	1 471	55	0.789	0.879
No. 4...............	Hard shale	0.12	0.18	0.77	2.66	0.89	1.32	20 824	3 965	89	0.334	0.496
	Soft shale	0.67	1.27	5.78	7.92	6.09	6.33	13 682	2 158	64	0.768	0.799
No. 5[b]...............	Hard shale	0.11	0.20	1.77	2.66	2.22	2.44	16 559	2 265	88	0.834	0.917
	Soft shale	1.13	1.94	7.33	9.70	8.55	8.85	11 502	1 561	62	0.881	0.913
No. 6...............	Hard shale	0.25	0.31	2.37	4.96	3.19	3.46	16 221	3 016	64	0.643	0.697
	Soft shale	1.18	2.23	7.67	9.95	7.72	8.76	10 373	1 757	53	0.776	0.880

[a] The fire clay brick had $\frac{3}{4}$-in. core holes.

[b] Brick from manufacturer No. 5 had $\frac{1}{4}$-in. core holes.

MR. H. Z. SCHOFIELD[1] (*presented in written form*).—The results and conclusions of Mr. McBurney's tests, showing as they do the magnitude of absorption variation resulting from procedure variation, point out clearly the safe limits to which one may go in interpreting methods of test. It is to be hoped that the proposed modification of the Tentative Specification for Building Brick, permitting forced cooling after the 5-hr. boiling test, will not be unconsciously abused. Obviously to reduce the temperature of a large sample of test specimens from 100 C. to a uniform temperature below 30 C. in 1 hr., the conditions of the proposed modification must be rigidly followed.

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[1] Director, Research Bureau, National Paving Brick Assn., Washington, D. C.

Regarding the proposal of a requirement in which the abilities of building bricks to withstand freezing and thawing will be classified by laboratory determinations of their physical properties, it would certainly seem that such a requirement is now appropriate in view of the justifying correlation which has been found. The proposed limits for absorption ratio are justified, although, for those bricks which have shown that they merit it by falling below a certain absorption value or above a certain compressive strength value, the absorption ratio can be omitted and the classification made on the basis of absorption or compressive strength limits.

REPORT OF COMMITTEE C-7
ON
LIME

Committee C-7 on Lime has held three meetings since the presentation of its report in 1934; one on June 28, 1934, in Atlantic City, N. J., one on June 24, 1935, in Detroit, Mich., and the other on March 4, 1936, in Pittsburgh, Pa., the latter during the Spring Group Meeting of A.S.T.M. Committees.

Two new members have been added to the committee; one member resigned and several changes have been made in representatives of corporate members. The membership of the committee now totals 39, classified as 19 producers, 7 consumers and 13 general interest members.

Contact has been established with the Technical Association of the Pulp and Paper Industry in anticipation of joint action in the preparation of specifications for Lime for various processes and methods in connection with pulp and paper making. Upon request, Chairman Withrow addressed a T.A.P.P.I. meeting in New York on the requirements of specifications for lime for use in the pulp and paper industry.

Action has been taken toward modifying the Tentative Methods of Physical Test for Limestone, Quicklime and Hydrated Lime (C 110 – 34 T) by withdrawing the autoclave method of test for soundness. Several alternative test methods for determining soundness of lime are under examination by various members of the committee.

The committee is undertaking the preparation of specifications for prepared lime plaster in view of the growing popularity and use of this commodity.

RECOMMENDATIONS AFFECTING STANDARDS

I. Proposed Revision of Tentative Standards.—The committee recommends that the following two tentative standards be revised as indicated below and continued as tentative:

Tentative Specifications for Sand for Use in Lime Plaster (C 66 – 31 T).[1]—There are at present two A.S.T.M. specifications for sand for use in plaster: namely, the Tentative Specifications for Sand for Use in Lime Plaster (C 66 – 31 T) prepared by Committee C-7, and the Standard Specifications for Sand for Use in Gypsum Plaster (C 35 – 30) under the jurisdiction of

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 738 (1931); also 1935 Book of A.S.T.M. Tentative Standards, p. 448.

Committee C-11 on Gypsum. Committee E-10 on Standards questioned the necessity for having two specifications for essentially the same product, the requirements of which are practically identical. On the recommendation of Committee E-10, a joint conference committee representing Committees C-7 and C-11 was accordingly appointed to give consideration to the feasibility of consolidating these specifications into a single standard. The joint committee, which was also assisted by a representative of the Sectional Committee on Specifications for Plastering (A.S.A. Project A 42), has formulated new proposed Tentative Specifications for Sand for Use in Plaster, appended hereto,[1] which are being jointly recommended by Committee C-7 and Committee C-11 for publication as tentative to replace the existing Specifications C 66 and C 35. Committee C-7 accordingly recommends that with the acceptance of these specifications by the Society as tentative,[2] its Tentative Specifications C 66 – 31 T be discontinued.

Tentative Methods of Physical Tests for Limestone, Quicklime and Hydrated Lime (C 110 – 34 T)[3].—Experience has indicated that the autoclave method of determining soundness as described in Sections 4 and 5 of these tentative methods is unsatisfactory since it is not indicative of field conditions. Pending the development of a simplified and improved test method, the committee recommends that the test procedure for constancy of volume appearing in Section 11 of the Standard Specifications for Hydrated Lime for Structural Purposes (C 6 – 31) be substituted for Sections 4 and 5 of the Tentative Methods C 110 – 34 T, as follows:[4]

Sections 4 and 5.—Delete the test for Soundness and in place thereof substitute the following procedure for determining constancy of volume:

Constancy of Volume.—Constancy of volume shall be determined as follows:

(*a*) To 20 g. of the sample, 100 g. of standard Ottawa sand shall be added, mixed thoroughly and enough water added to the mixture to make a good plastic mortar of rather dry consistency. This shall be spread on a clean glass plate to form a layer about ½ in. in thickness by 4 in. square. The pat shall be of even thickness throughout, and not tapering at the edges. If the mortar is too dry to work well, more water may be added. The pat shall be placed in a closet for 24 hr. The temperature in the closet shall be between 65 and 75 F. (18 and 24 C.), and there shall be free circulation of air, but no direct draft striking the pat. The pat shall then be soaked in water until a film of water stands unabsorbed on the surface of the pat. If the pat has cracked, the consistency of the mortar was too wet and a new pat must be made. Two or three pats made at the same time from mortars of slightly different consistencies will avoid delays.

(*b*) A 20-g. portion of the sample shall be mixed with enough water to form a thick cream. This shall be spread in a thin layer on the surface of the pat. It shall be allowed to stand for 15 min. to permit air bubbles to form. It shall be troweled to an even surface, making this skim coat as thin as possible without allowing the sand to show through. The pat shall be put in the closet, under the conditions specified above, for 24 hr. It shall be examined carefully to see that there are no cracks or pops. The pat shall be suspended in a vessel partially filled with cold water, in such a way that the water can boil without touching the pat. The water shall be brought gradually to boiling and kept boiling gently for 5 hr., the pat being surrounded by steam during this time. The water shall then be permitted to cool for at least 12 hr. The pat shall then be removed and examined.

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[1] See p. 771.

[2] This recommendation was concurred in by Committee C-11 on Gypsum, the results of the letter ballot in Committee C-11 being as follows: of 25 ballots returned from a committee membership of 26, 18 voted affirmatively, 1 negatively and 6 ballots were marked "not voting."—ED.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, p. 754 (1934); also 1935 Book of A.S.T.M. Tentative Standards, p. 450.

[4] This recommended revision of the Tentative Methods of Physical Test for Limestone, Quicklime and Hydrated Lime (C 110 – 34 T) was presented to the Society at the annual meeting, see Summary of Proceedings, page 22, and on motion, after discussion, was referred back to Committee C-7 on Lime for further consideration, the autoclave test to be retained in the tentative methods until this matter had been given further study by the committee.—ED.

The recommendations appearing in this report have been submitted to letter ballot of the committee, which consists of 39 members; the results being as follows:

Items	Affirmative	Negative	Ballots Marked "Not Voting"
I. PROPOSED REVISIONS OF TENTATIVE STANDARDS			
Specifications for Sand for Use in Lime Plaster (C 66 – 31 T)	23	0	4
Methods of Physical Test for Limestone, Quicklime and Hydrated Lime (C 110 – 34 T)[a]	19	5	5

[a] The classified vote on the proposed revision of these Tentative Methods was as follows: Affirmative: 10 producers, 2 consumers, 7 general interests; negative: 2 producers, 1 consumer, 2 general interests; not voting: 2 producers, 3 consumers.

The election of officers resulted in the selection of the following for the ensuing term of two years:

Chairman, James R. Withrow.
Vice-Chairman, E. E. Eakins.
Vice-Chairman, L. S. Wells.
Secretary, Lee S. Trainor.

This report has been submitted to letter ballot of the committee which consists of 39 members; 27 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

JAMES R. WITHROW,
Chairman.

LEE S. TRAINOR,
Secretary.

REPORT OF COMMITTEE C-8
ON
REFRACTORIES

Committee C-8 on Refractories held two meetings during the year; in Washington, D. C., at the National Bureau of Standards, on October 9, 1935; and in Columbus, Ohio, on March 30, 1936, the latter in conjunction with the annual meeting of the American Ceramic Society.

The committee has continued its active work during the year. The volume of A.S.T.M. Standards on Refractory Materials has been well received, and more consumers of refractories are using A.S.T.M. standards than ever before.

A new set of by-laws has been adopted by the committee, and certain changes made in the organization of subcommittees which it is believed will increase the operating efficiency of the committee as a whole.

One member of the committee visited several European countries endeavoring to obtain their attitude toward the work of the International Standards Association with respect to standards for refractory materials.

RECOMMENDATIONS AFFECTING STANDARDS

The recommendations of the committee regarding standards and tentative standards under its jurisdiction are summarized below, together with the analysis of the letter ballot on each item.

I. Proposed Tentative Standard:

Proposed Tentative Method of Panel Test for Resistance to Thermal and Structural Spalling of Super Duty Fireclay Brick.—It has been found that the preheat temperature in the Tentative Method of Panel Test for Resistance to Thermal and Structural Spalling of Fireclay Brick for Stationary Boilers and Malleable Iron Furnace Bungs (C 107 – 34 T) is not severe enough to bring out the differences between high heat duty brick and super duty fireclay brick. The committee, therefore, recommends for publication as tentative a new method of panel test for spalling, as appended hereto,[1] wherein a preheat temperature of 1650 C. is used.

II. Revision of Tentative Standard:

Tentative Definitions of Terms Relating to Refractories (C 71 – 35 T).[2]—The committee recommends that the definitions of the terms, "insulating brick," "insulating fire brick," "calcining," "burning (firing)," and "hard burned, medium burned, light burned" be revised, as appended hereto,[1] and continued as tentative.

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[1] See p. 785.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 811 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 555.

III. Revision of Standard:

Standard Definitions for Fireclay Refractories (*C 27 - 35*).[2]—The committee recommends that the definition for the term, "super duty fireclay brick," published in 1935 as a tentative revision of the Standard Definition C 27, be revised as given below and continued as tentative, to be subsequently incorporated when adopted as standard in these Definitions for Fireclay Refractories.

Change from its present form: namely,

> *Super Duty Fireclay Brick.*—The Pyrometric Cone Equivalent of super duty fireclay brick shall not be lower than that of Standard Pyrometric Cone No. 33, when tested on the fired product. The alumina content shall be not less than 40 per cent. In the panel spalling test, these brick shall not lose more than 1.0 per cent. In the test for permanent linear change after reheating, schedule C, the brick shall not show more than 0.5 per cent shrinkage.

to read as follows:

> *Super Duty Fireclay Brick.*—A fireclay brick having a P. C. E. not lower than Cone No. 33 on the fired product, determined in accordance with the Standard Method of Test for Pyrometric Cone Equivalent of Fire Clay and Fire Brick (A.S.T.M. Designation: C 24); a shrinkage of not more than 1 per cent, determined in accordance with Section C of the Tentative Method of Test for Permanent Linear Change After Reheating of Refractory Brick (A.S.T.M. Designation: C 113 - 34 T); and an average loss in spalling test of not more than 4 per cent, determined in accordance with the Tentative Method of Panel Test for Resistance to Thermal and Structural Spalling of Super Duty Fireclay Brick (A.S.T.M. Designation: C 122 - 36 T) of the American Society for Testing Materials.

IV. Adoption of Tentative Standards as Standard:

The committee recommends that the following four tentative specifications, four tentative methods and one definition be referred to letter ballot of the Society for adoption as standard without revision:

Tentative Specifications for:

Clay Fire Brick for Malleable Furnaces with Removable Bungs and for Annealing Ovens (C 63 - 34 T)[3]
Clay Fire Brick for Stationary Boiler Service (C 64 - 34 T)[3]
Ground Fire Clay (C 105 - 34 T)[4]
Refractories for the Construction of Incinerators (C 106 - 34 T)[4]

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[1] See p. 787.
[2] 1935 Supplement to Book of A.S.T.M. Standards, p. 118.
[3] A.S.T.M. Standards on Refractory Materials, Special Reprint, pp. 1, 5, (1935).
[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, pp. 780, 782 (1934); also 1935 Book of A.S.T.M. Tentative Standards, pp. 530, 532.

Tentative Methods of:

- Panel Test for Resistance of Refractory Brick to Thermal and Structural Spalling (C 38 – 34 T)[1]
- Test for Particle Size of Ground Refractory Material (C 92 – 34 T)[2]
- Panel Test for Resistance to Thermal and Structural Spalling of Fireclay Brick for Stationary Boilers and Malleable Iron Furnace Bungs (C 107 – 34 T)[1]
- Test for Permanent Linear Change After Reheating of Refractory Brick (C 113 - 34 T)[2]
- Tentative Definition of the Term "Grog Fire-Clay Mortar," appearing in the Tentative Definitions of Terms Relating to Refractories (C 71 – 35 T)[3]

V. Adoption of Tentative Revision of Standard as Standard:

Standard Method of Test for Refractory Materials Under Load at High Temperatures (C 16 – 20).[4]—As no objections have been received during the year to the tentative revisions[2] of this standard method, the committee recommends that they be approved for reference to letter ballot of the Society for adoption as standard.

VI. Withdrawal of Approval of Standard:

Standard Methods of Testing Brick (Compression, Flexure, Absorption) (C 67 – 31).—In view of the fact that these methods, which were developed by Committee C-3 on Brick and are used primarily for testing paving and building brick, are not well suited for testing refractory brick and since a new procedure is being formulated for fire brick, Committee C-8 is withdrawing the formal approval which it gave in 1932 for use in testing refractories of the modulus of rupture or flexural strength test described in these methods.

The recommendations appearing in this report have been submitted to letter ballot of the committee which consists of 37 members, the results being as shown in Table I:

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Tests and Specifications (M. E. Holmes, chairman):

This subcommittee has proposed that a more severe panel spalling test be adopted for differentiating super duty fireclay brick from regular first-quality brick. A preheat temperature of 1650 C. instead of 1600 C. seems to bring out the difference. The subcommittee accordingly recommends that the title of the panel spalling test (C 107 – 34 T) be changed to read "Tentative Method of Panel Test for Resistance to Thermal and Structural Spalling of High Heat Duty Fireclay Brick," this change to be made as an editorial matter.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, pp. 796, 804 (1934); also 1935 Book of A.S.T.M. Tentative Standards, pp. 390, 398.

[2] A.S.T.M. Standards on Refractory Materials, Special Reprint, pp. 28, 41, 49 (1935).

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 811 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 555.

[4] 1933 Book of A.S.T.M. Standards, Part II, p. 179.

Section on Abrasion (J. M. McKinley, chairman) has made a review of the literature on abrasion tests.

Section on Analysis (L. J. Trostel, chairman) is preparing specific methods of analysis for fireclay, silica, high alumina, and other types of refractories. An arrangement has also been made to conduct a study on the determination of the FeO content of chrome ore. The National Bureau of Standards will be requested to prepare standard samples of refractories for specific gravity determinations.

TABLE I.—ANALYSIS OF LETTER BALLOT VOTE.

Items	Affirmative	Negative	Ballots Marked "Not Voting"
I. PROPOSED TENTATIVE STANDARD			
Method of Panel Test for Resistance to Thermal and Structural Spalling of Super Duty Fireclay Brick	30	1	2
II. REVISION OF TENTATIVE STANDARD			
Definitions of Terms Relating to Refractories (C 71 – 35 T):			
Insulating Brick	26	7	3
Insulating Fire Brick	21	9	6
Calcining	28	3	5
Burning (Firing)	30	3	3
Hard-Burned Refractory Ware	27	2	7
Light-Burned Refractory Ware	27	2	7
Medium-Burned Refractory Ware	27	2	7
III. REVISION OF STANDARD			
Definitions for Fireclay Refractories (C 27 – 35):			
Super Duty Fireclay Brick	29	1	3
IV. ADOPTION OF TENTATIVE STANDARDS AS STANDARD			
Specifications for Clay Fire Brick for Malleable Furnaces with Removable Bungs and for Annealing Ovens (C 63 – 34 T)	28	0	5
Specifications for Clay Fire Brick for Stationary Boiler Service (C 64 – 34 T)	29	0	4
Specifications for Ground Fire Clay (C 105 – 34 T)	34	1	2
Specifications for Refractories for the Construction of Incinerators (C 106 – 34 T)	26	0	7
Method of Panel Test for Resistance of Refractory Brick to Thermal and Structural Spalling (C 38 – 34 T)	29	0	4
Method of Test for Particle Size of Ground Refractory Material (C 92 – 34 T)	29	1	3
Method of Panel Test for Resistance to Thermal and Structural Spalling of Fireclay Brick for Stationary Boilers and Malleable Iron Furnace Bungs (C 107 – 34 T)	30	0	3
Method of Test for Permanent Linear Change After Reheating of Refractory Brick (C 113 – 34 T)	27	1	5
Definitions of Terms Relating to Refractories (C 71 – 35 T):			
Grog Fire-Clay Mortar	30	0	3
V. ADOPTION OF TENTATIVE REVISION OF STANDARD AS STANDARD			
Method of Test for Refractory Materials Under Load at High Temperatures (C 16 – 20)	29	1	3
VI. WITHDRAWAL OF APPROVAL OF STANDARD			
Methods of Testing Brick (Compression, Flexure, Absorption) (C 67 – 31)	24	7	2

Section on Load (C. M. Dodd, chairman) is preparing new methods for testing fire brick for compression, flexure and absorption. The same methods may also be applicable to insulating fire brick.

Section on Precision and Tolerance (F. A. Harvey, chairman) has recommended that a study be made of the P.C.E. test to determine the precision of the method. Some work has been done on this subject by the Mellon Institute, National Bureau of Standards and others. The cold crushing strength of refractories is also being studied.

Section on Slagging (W. A. Carter, chairman) is conducting some modified Hursh slag tests on several brands of brick and will then observe the effect of slagging on these brick in service.

Section on Spalling (R. E. Birch, chairman).—Tests have been made in the panel spalling test where the brick were laid as headers instead of stretchers. The data indicate that so long as the heat gradient through the brick was not disturbed, the spalling losses were essentially the same.

Section on Temperature (R. B. Sosman, chairman) has made a very comprehensive study of pyrometric cones. This section is now studying P.C.E. test furnaces with the hope of eventually recommending for adoption a standard test furnace for P.C.E.

Subcommittee II on Research (S. M. Phelps, chairman):

This subcommittee has done considerable work on the panel spalling test. The present test does not clearly separate high heat duty brick from super duty fireclay brick, but it has been shown that a preheat temperature of 1650 C. instead of 1600 C. will bring out the difference. Some work has been done toward refinement of the panel test method, such as mechanical regulation of the water pressure, a timing mechanism to control the flow of water, shifting of the panels, etc.

Subcommittee III on Nomenclature (A. S. Watts, chairman):

This subcommittee has prepared the revised definitions of the terms "insulating brick," "insulating fire brick," "calcining," "burning (firing)," and "hard burned, light burned, medium burned refractory ware," which are appended hereto[1] under the title, "Tentative Definitions of Terms Relating to Refractories (C 71 – 36 T)." The subcommittee is also recommending that the definition for the term "super duty fireclay brick," proposed last year, be revised as given earlier in this report and accepted for publication as a tentative revision to be subsequently incorporated when adopted as standard in the Standard Definitions for Clay Refractories (C 27 – 35).

Subcommittee IV on Industrial Survey (L. C. Hewitt, chairman):

A preliminary survey has been prepared on the refractory service conditions in continuous bottle-tank furnaces in the glass industry.

Subcommittee V, Editorial (L. J. Trostel, chairman):

This subcommittee has been very active during the year and several clarifying changes are to be made in a number of the test methods.

Subcommittee VI on Heat Transfer and Refractory Insulation (R. H. Heilman, chairman):

Considerable work has been done by this subcommittee in developing a standard method for determining the thermal conductivity of refractory materials. Tentative apparatus has been designed and it is hoped that the National Bureau of Standards can be induced to cooperate in this study.

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[1] See p. 787.

At the meeting held in Columbus, Ohio, the following were elected to direct the affairs of the committee for the ensuing term of two years:

John D. Sullivan, Chairman;
E. H. Van Schoick, Vice-Chairman;
C. E. Bales, Secretary.

This report has been submitted to letter ballot of the committee which consists of 37 members; 32 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

R. A. HEINDL,
Chairman.
E. H. VAN SCHOICK,
Vice-Chairman.

C. E. BALES,
Secretary.

REPORT OF COMMITTEE C-9

ON

CONCRETE AND CONCRETE AGGREGATES

Committee C-9 on Concrete and Concrete Aggregates has held three meetings during the year, the first in Washington, D. C., on December 7, 1935, the second in Pittsburgh, Pa., on March 5, 1936, in conjunction with the spring group meetings of A.S.T.M. committees, and the third in Atlantic City, N. J., in conjunction with the annual meeting of the Society.

The year's work has resulted in recommendations for three new tentative methods of test and tentative definitions of six terms; revisions of one tentative standard and three standards; the adoption as standard of four tentative methods of test and one tentative specification; and the adoption as standard of tentative revisions in one standard.

The following papers are presented in Appendices I to IV to this report:

"Apparatus and Technique for the Bureau of Reclamation Concrete Permeability Tests," prepared by E. N. Vidal and G. A. Samson and submitted by Subcommittee VIII on Permeability Tests of Concrete.

"Studies on Relation Between Characteristics of Blast-Furnace Slag and Other Coarse Aggregates and the Properties of Resultant Concretes," prepared by Fred Hubbard and submitted by Subcommittee IX on Specifications and Methods of Tests of Aggregates.

"Studies of Sodium and Magnesium Sulfate Soundness Tests," prepared by Stanton Walker and C. E. Proudley and also submitted by Subcommittee IX.

"Shrinkage of Haydite and Sand-Gravel Concrete," prepared by F. E. Richart and J. E. Keranen and submitted by Subcommittee XVI on Elasticity and Volume Changes of Concrete.

RECOMMENDATIONS AFFECTING STANDARDS

I. Proposed Tentative Standards.—The committee submits for publication as tentative the following three methods of test and one list of definitions of terms:

Proposed Tentative Method of Test for Flow of Portland-Cement Concrete by Use of the Flow Table.—This tentative method which is appended hereto[1] was prepared by Subcommittee VII on Methods and Apparatus for Testing Concrete (A. T. Goldbeck, chairman).

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[1] See p. 803.

Proposed Tentative Laboratory Method of Making Flexure Tests of Concrete Using a Simple Beam with Third Point Loading.—This method as appended hereto[1] was also proposed by Subcommittee VII and is to replace the present Tentative Method of Making Flexure Tests of Concrete Using a Simple Beam with Center Loading (C 78 - 30 T) in order to conform with the method of the American Association of State Highway Officials, inasmuch as state highway departments are the principal users of the method.

Proposed Tentative Method of Test for Determination of Coal and Lignite in Sand.—This tentative method as appended hereto[2] was prepared by Subcommittee IX on Specifications and Methods of Tests of Aggregates (H. F. Clemmer, chairman).

Proposed Tentative Definitions of Terms Relating to Concrete and Concrete Aggregates.—These tentative definitions, which are appended hereto[3] and which define the terms "admixture," "blast furnace slag," "crushed stone," "fineness modulus," "gravel" and "crushed gravel," were prepared by Subcommittee V on Definitions (Cloyd M. Chapman, chairman).

II. Revision of Tentative Standard.—The committee recommends that the Tentative Specifications for Concrete Aggregates (C 33 - 31 T)[4] be revised as follows as proposed by Subcommittee IX on Specifications and Methods of Tests of Aggregates (H. F. Clemmer, chairman) and continued as tentative:

Section 3.—Change the limits for grading of fine aggregate from its present form: namely,

	Per Cent
Passing a ⅜-in. sieve	100
Passing a No. 4 sieve	(85) to (100)
Passing a No. 16 sieve	(45) to (80)
Passing a No. 50 sieve	(2) to (30)
Passing a No. 100 sieve	(0) to (5)

to read as follows:

	Per Cent
Passing a ⅜-in. sieve	100
Passing a No. 4 sieve	(95) to (100)
Passing a No. 16 sieve	(45) to (80)
Passing a No. 50 sieve	(5) to (30)
Passing a No. 100 sieve	(0) to (8)

III. Revisions of Standards.—The committee recommends for immediate adoption the following revisions in three standard specifications and accordingly asks for the necessary nine-tenths vote at the annual meeting in order that these revisions may be referred to letter ballot of the Society for immediate adoption as standard:

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[1] See p. 796.

[2] See p. 794.

[3] See p. 811.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 759 (1931); also 1935 Book of A.S.T.M. Tentative Standards, p. 578.

Standard Specifications for Curing Portland-Cement Concrete Slabs with Bituminous Coverings (C 81 – 34):[1]

Section 4.—Change Paragraph (*b*) to read as follows by the addition of the italicized words and the omission of those in brackets:

(*b*) Wet Burlap Covering.—If for any reason the application of the bituminous curing material to any portion of the concrete surface cannot proceed at the proper time, that portion shall be covered immediately with *a double thickness of* wet burlap, which shall be kept wet until the concrete has set. [The burlap shall be removed before 10.00 a. m. the following day, and the concrete immediately coated with the bituminous curing material.]

Standard Specifications for Curing Portland-Cement Concrete Slabs with Wet Coverings (C 84 – 34):[1]

Section 4.—Change this section to read as follows by the addition of the italicized words and the omission of those in brackets:

4. The [edges] *sides* of a slab exposed by the removal of the forms shall be protected immediately after the form removal in such a manner as to give these surfaces curing treatment equivalent to that provided by one of the [preceding] methods *prescribed for the surface.*

Standard Specifications for Curing Portland-Cement Concrete Slabs by Surface Application of Calcium Chloride (C 83 – 34):[1]

New Section.—Add the following as a new Section 5:

5. The sides of a slab exposed by the removal of the forms shall be protected immediately after the form removal in such a manner as to give these surfaces curing treatment equivalent to that provided by the methods prescribed for the surface.

IV. Adoption of Tentative Standards as Standard.—The committee recommends that the following tentative methods of tests and tentative specification which have been in satisfactory use be approved for reference to letter ballot of the Society for adoption as standard:

Tentative Method of Making Compression Tests of Concrete Using Portions of Beams Broken in Flexure (C 116 – 35 T),

Tentative Method of Test for Structural Strength of Fine Aggregate Using Constant Water-Cement-Ratio (C 87 – 32 T),

Tentative Method of Test for Absorption by Aggregates for Concrete (Laboratory Determinations) (C 95 – 33 T),

Tentative Method of Field Test for Absorption of Mixing Water by Aggregates for Concrete (C 96 – 33 T),

Tentative Specifications for Sodium Silicate for Curing Concrete (C 111 – 34 T), and

Tentative Method of Routine Analysis of the Cement Content of Hardened Portland-Cement Concrete (C 85 – 31 T).

V. Adoption of Tentative Revisions of Standard as Standard.—The committee recommends that the tentative revisions in the Standard Method of Test for Sieve Analysis of Aggregates for Concrete (C 41 – 33), as presented last year,[1] be approved for reference to letter ballot of the Society for adoption as standard.

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[1] 1934 Supplement to Book of A.S.T.M. Standards, pp. 104, 108, 107.

VI. Withdrawal of Tentative Standard.—The committee recommends the withdrawal of the Tentative Method of Making Flexure Tests of Concrete Using a Simple Beam with Center Loading (C 78 – 30 T), since another method has been recommended as a replacement of this test for reasons mentioned earlier in this report.

TABLE I.—ANALYSIS OF LETTER BALLOT VOTE.

Items	Affirmative	Negative	Ballots Marked "Not Voting"
I. PROPOSED TENTATIVE STANDARDS			
Tentative Method of Test for Flow of Portland-Cement Concrete by Use of the Flow Table	32	0	1
Laboratory Method of Making Flexure Tests of Concrete Using a Simple Beam with Third Point Loading	33	0	1
Method of Test for Coal and Lignite in Sand	31	0	2
Definitions of Terms Relating to Concrete and Concrete Aggregates:			
Admixture	32	0	1
Blast Furnace Slag	31	1	1
Crushed Stone	32	0	1
Fineness Modulus	32	0	1
Gravel	32	0	1
Crushed Gravel	30	1	2
II. PROPOSED REVISION OF TENTATIVE STANDARD			
Specifications for Concrete Aggregates (C 33 – 31 T)[a]	27	4	2
III. REVISIONS OF STANDARDS			
Specifications for Curing Portland-Cement Concrete Slabs with Bituminous Coverings (C 81 – 34), immediate adoption	31	1	1
Specifications for Curing Portland-Cement Concrete Slabs with Wet Coverings (C 84 – 34), immediate adoption	31	1	1
Specifications for Curing Portland-Cement Concrete Slabs by Surface Application of Calcium Chloride (C 83 – 34), immediate adoption	31	1	0
IV. ADOPTION OF TENTATIVE STANDARDS AS STANDARD			
Method of Making Compression Tests of Concrete Using Portions of Beams Broken in Flexure (C 116 – 35 T)	31	0	2
Method of Test for Structural Strength of Fine Aggregate Using Constant Water-Cement Ratio Mortar (C 87 – 32 T)	30	1	2
Method of Test for Absorption by Aggregates for Concrete (Laboratory Determinations) (C 95 – 33 T)[b]	28	4	1
Method of Field Test for Absorption of Mixing Water by Aggregates for Concrete (C 96 – 33 T)	30	2	1
Method of Routine Analysis of the Cement Content of Hardened Portland-Cement Concrete (C 85 – 31 T)	27	2	4
Specifications for Sodium Silicate for Curing Concrete (C 111 – 34 T)	26	2	5
V. ADOPTION OF TENTATIVE REVISION OF STANDARD AS STANDARD			
Test for Sieve Analysis of Aggregates for Concrete (C 41 – 33)	32	0	1
VI. WITHDRAWAL OF TENTATIVE STANDARD			
Method of Making Flexure Tests of Concrete Using a Simple Beam With Center Loading (C 78 – 30 T)	30	0	2

[a] The classified vote on the revision of the Tentative Specifications for Concrete Aggregates was as follows: Affirmative: 7 producers, 10 consumers, 10 general interests; negative: 1 producer, 3 consumers, 0 general interests.

[b] The classified vote on the adoption as standard of the Tentative Method of Test for Absorption by Aggregates for Concrete (Laboratory Determinations) was as follows: Affirmative: 4 producers, 13 consumers, 11 general interests; negative: 3 producers, 1 consumer, 0 general interests.

VII. Tentative Standard Continued as Tentative.—While it is recognized that the Tentative Method of Test for Apparent Specific Gravity of Coarse Aggregates in a Saturated Condition (C 86 – 31 T) covers a definite need, it is felt that more time must be allowed for its trial, and it is accordingly recommended that it be continued as tentative.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1395 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 1521.

The recommendations appearing in this report have been submitted to letter ballot of the committee, which consists of 61 members, with the results shown in Table I.

The election of officers for the ensuing term of two years resulted as follows:

Chairman, R. W. Crum
Vice-Chairman, Stanton Walker
Secretary, R. R. Litehiser
Chairman of Finance Committee, H. J. Love

Members-at-Large of Executive Committee:
F. R. McMillan
A. T. Goldbeck
F. E. Richart
F. H. Jackson
J. C. Pearson
C. M. Chapman
C. H. Scholer
H. F. Clemmer

In appreciation of his invaluable service to the committee ever since its inception, Dr. A. N. Talbot was unanimously elected Honorary Chairman.

This report has been submitted to letter ballot of the committee which consists of 61 members; 33 members have returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

R. W. CRUM,
Chairman.

R. R. LITEHISER,
Secretary.

EDITORIAL NOTE

Subsequent to the annual meeting Committee C-9 on Concrete and Concrete Aggregates in cooperation with Committee D-4 on Road and Paving Materials presented to the Society on August 26, 1936, through Committee E-10 on Standards the following two proposed tentative methods of test:

Proposed Tentative Methods of:

Test for Specific Gravity and Absorption of Coarse Aggregate, to replace the existing Tentative Method of Test for Apparent Specific Gravity of Coarse Aggregates in a Saturated Condition (C 86 – 31 T) and the Standard Method of Test for Apparent Specific Gravity of Coarse Aggregates (D 30 – 18).

Test for Specific Gravity and Absorption of Fine Aggregate, to replace the existing Standard Methods of Test for Approximate Apparent Specific Gravity of Fine Aggregate (C 68 – 30) and for Apparent Specific Gravity of Sand, Stone and Slag Screenings, and Other Fine Non-Bituminous Highway Materials (D 55 – 25).

The proposed tentative methods of test were accepted and appear on pp. 805 and 808, respectively.

APPENDIX I

APPARATUS AND TECHNIQUE FOR THE BUREAU OF RECLAMATION CONCRETE PERMEABILITY TESTS

By E. N. Vidal[1] and G. A. Samson[1]

Introduction

This paper attempts to treat thoroughly the problems involved in the mechanics of testing for permeability and describes in detail the apparatus and technique developed to meet the demands of an engineering organization. The accuracy of test results is discussed briefly. The actual tests and conclusions drawn therefrom have been presented elsewhere[2] and hence are omitted from this report.

Apparatus and Technique

Apparatus:

The permeability test apparatus includes two types, with eight units so constructed as to test concrete of full mass mixes at high pressures up to 400 lb. per sq. in. and sixteen units for tests at pressures up to 100 lb. per sq. in.

The high-pressure type was a development resulting from the Boulder Dam mass concrete test program, in which it was planned to parallel strength and permeability tests with respect to size of aggregate. This program covered a range of mixes in which the aggregate varied from a $\frac{3}{4}$ in., max., up to a 9 in., max. It was felt that, as in strength tests, a test specimen representative of the concrete to be tested should have a minimum diameter and length of at least two to four times the maximum size of aggregate. The maximum specimen size was accordingly set at 18 in. in diameter and 18 in. in length, with others 12 by 12, 8 by 8, and 6 by 12 in. Since the variation in lengths would prevent direct comparison of the test results, the 6-in. diameter container was designed to handle a 12-in. length, so that the permeability length relation might be established. As the tests progressed, it was found necessary to increase this length to 24 in. by means of sleeves.

The containers were designed to permit entrance of the water over the entire top surface of the concrete, passing through and out the bottom, with no flow in or out of the sides. This was accomplished by means of the containers as shown in Figs. 1 and 2. The clearances between the concrete and the inner wall of the containers were determined by a consideration of the proposed sealing materials, at that time expected to be principally asphaltic. In using this material, it was necessary to provide ample space for the pouring of a fairly viscous fluid. For preliminary tests, two containers for the 8 by 8-in. specimens were made, having an inside diameter providing a $\frac{1}{2}$-in. clearance on all sides of the specimen. Successful sealing was accomplished with an asphaltic pipe joint compound and this clearance was accepted as adequate. The other containers were, therefore, made similarly.

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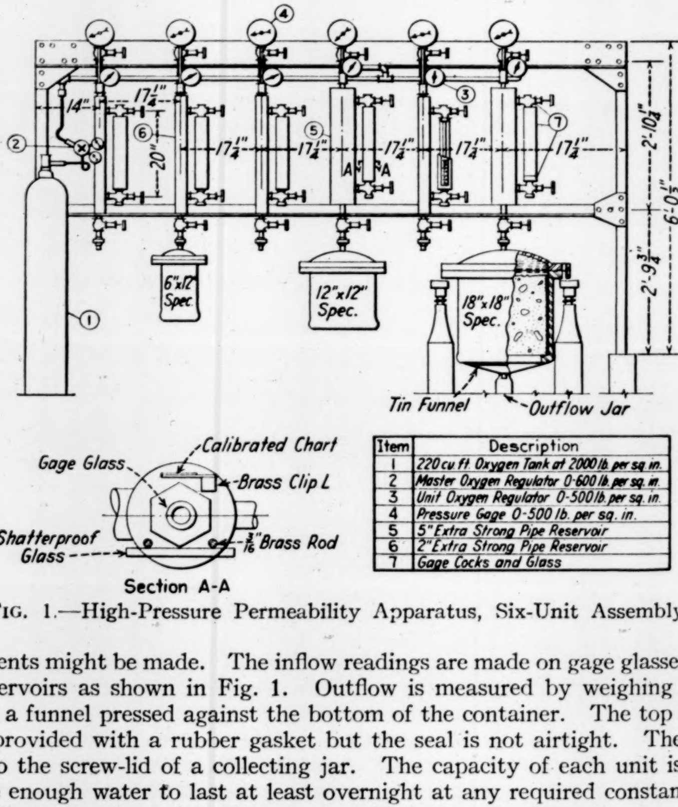
[1] Associate Engineer, and Assistant Engineer, respectively, Bureau of Reclamation, Denver, Colo.

[2] Arthur Ruettgers, E. N. Vidal and S. P. Wing, "An Investigation of the Permeability of Mass Concrete with Particular Reference to Boulder Dam." *Journal*, Am. Concrete Inst., Vol. 6, No. 4, p. 382 (1935). Discussions by M. Mary, R. W. Carlson, Paul T. Norton, Jr., and D. H. Pletta appeared in *Journal*, Am. Concrete Inst., Vol. 7, No. 1, p. 125 (1935), and by S. L. Meyers in *Journal*, Am. Concrete Inst., Vol. 7, No. 2, p. 230 (1935). The authors' closure was presented in *Journal*, Am. Concrete Inst., Vol. 7, No. 3, p. 378 (1936).

The containers were designed to withstand a hydrostatic pressure of 500 lb. per sq. in. Cast nickel steel was used, and no difficulty was experienced with sand-hole leaks or other failures. A machined ledge was provided at the bottom to insure a proper seat for the test cylinders and also to prevent the sealing compound from squeezing out. The top flange was machined to insure proper gasket seating and a $\frac{1}{16}$-in. lead ring gasket proved to be the most satisfactory of those tried. The extension sleeves for the 6-in. containers were made of the same material, and so constructed that they could be bolted to the upper flange of the 12-in. long container, and the lid in turn to the upper flange of the sleeve.

It was expected that for tests on concrete specimens of the planned lengths and mixes, measurable outflow would be difficult, if not impossible, to obtain on some cylinders. The apparatus was accordingly made so that both inflow and outflow measurements might be made. The inflow readings are made on gage glasses attached to the reservoirs as shown in Fig. 1. Outflow is measured by weighing the water caught by a funnel pressed against the bottom of the container. The top rim of the funnel is provided with a rubber gasket but the seal is not airtight. The funnel is soldered to the screw-lid of a collecting jar. The capacity of each unit is sufficient to provide enough water to last at least overnight at any required constant pressure up to 500 lb. per sq. in. and facilities are provided for easily filling the reservoirs with water. The pressure supply source is an ordinary oxygen tank at 2000 lb. per sq. in. from which the main-line pressure is reduced to about 600 lb. per sq. in. by means of a master regulator. The main line is in turn connected to the reservoirs by individual regulators of the heavy oxygen-cutting type, capable of transmitting pressures of 0 to 500 lb. per sq. in. as desired, to the reservoir. In the assembling of the apparatus, all pipe, fittings, and valves were extra strong, and the joints were set up with a mixture of litharge and glycerin. No difficulty has been experienced with joint leaks of any kind.



Item	Description
1	220 cu. ft. Oxygen Tank at 2000 lb. per sq. in.
2	Master Oxygen Regulator 0-600 lb. per sq. in.
3	Unit Oxygen Regulator 0-500 lb. per sq. in.
4	Pressure Gage 0-500 lb. per sq. in.
5	5" Extra Strong Pipe Reservoir
6	2" Extra Strong Pipe Reservoir
7	Gage Cocks and Glass

FIG. 1.—High-Pressure Permeability Apparatus, Six-Unit Assembly.

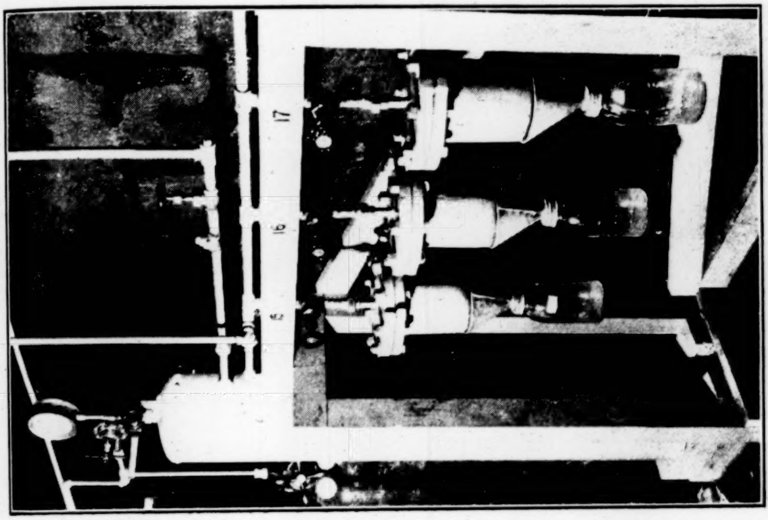


FIG. 3.—Low-Pressure Permeability Apparatus.

Partial view showing three of the 16 units, with the water reservoir and pressure tank in the left background.

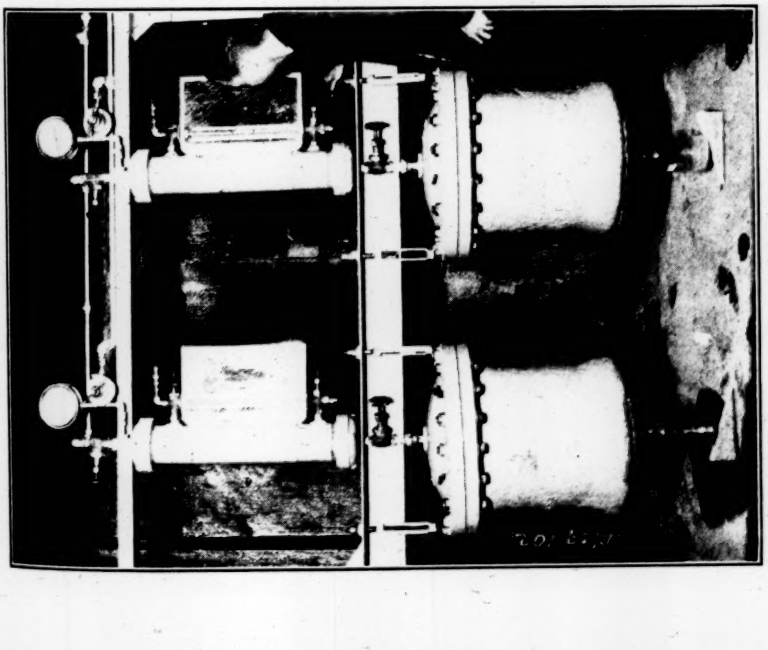


FIG. 2.—High-Pressure Permeability Apparatus, Auxiliary Double Unit Specially Constructed for 18 by 18-in. Specimens.

The low-pressure apparatus (Fig. 3) was designed to meet a need for quantity production of tests planned for the effect of leaching and in connection with cement investigations which required routine tests for comparison of cements. As these comparisons could be made with a lean mix, it was not necessary to use high-pressure apparatus, or to arrange for measurements of inflow. As a matter of economy, it was therefore decided to use 6-in. diameter by 2-in. thick disks for specimens tested at 100 lb. per sq. in., and to measure outflow only. The containers are of the type[1] developed at the Portland Cement Association laboratory and consist of 6 by 8-in. long double extra heavy pipe nipples, machined out to an inside diameter of 6⅛ in. and to a depth of 6 in., leaving a ledge ⅜ in. wide at the bottom for seating the specimen. An ordinary flange is screwed to the top end and brazed in place. The top is closed by bolting on a standard blind flange, using a rubber ring gasket, and the blind flange is tapped for a ½-in. pipe which is connected to the supply line. Each unit is directly controlled by a globe valve between the containers and the supply line, which has as its reservoir a 30-gal., extra-heavy, range boiler. Supplied by oxygen tanks, the pressure is maintained at 100 lb. per sq. in. for all units on the line and is controlled by one oxygen regulator valve at the inlet of the reservoir tank.

Although a rather substantial number of tests have been made on the 2-in. thick disks, very few results were obtained of sufficient accuracy to be usable. Apparently, the end effect on such a relatively thin specimen tends to overshadow any other variables which might be involved. Successful tests have been completed on 6-in. thick specimens in this apparatus with results of reasonable uniformity.

All apparatus of both types is installed in air-conditioned rooms with the temperature maintained at 70 F. ± 2 deg. Fahr. and a relative humidity of 80 ± 5 per cent. This eliminates any necessity for temperature corrections and minimizes outflow evaporation losses, which are, nevertheless, found to be 0.005 in. per day from a free water surface. Appropriate corrections are applied to computations based on outflow measurements to compensate for this loss.

Technique:

A large number of failures of specimens under test was experienced during the early stages of the program even after the apparatus itself had been found sufficient. In general, the failures were caused by faulty seals and it has been only through the greatest possible care in developing a technique from a long and thorough process of step-by-step elimination that the problem has been solved to any degree of satisfaction. Even at present, occasionally a seal failure will occur in spite of all the precautions taken, but is is believed that the technique outlined hereafter guarantees successful tests for nine out of ten attempts.

Two types of compounds have been used successfully to seal the specimens. For the high-pressure units, G-K pipe joint compound, a commercial asphaltic product, has been used. At present, a mixture of equal parts by weight of paraffin and resin is being used for all units. In the low-pressure units, it may be noted that the seal space is only $\frac{1}{16}$ in. wide, which necessitates the use of a sealing compound of very thin consistency.

In using either compound, success appears to depend almost entirely upon the surface condition of the test specimen. It must be dry, free from oil or grease which usually adheres from the casting molds, and with all loose material brushed off. To insure these conditions, the test specimens are surfaced-dried in the laboratory air, cleaned very thoroughly with a rotating wire brush, slightly roughened with medium emery cloth, and finally washed with gasoline which is allowed to evaporate. It has been found that no attention need be paid to the container surface, as the seal bonds readily to the steel.

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[1] F. R. McMillan and Inge Lyse, "Some Permeability Studies of Concrete," *Proceedings*, Am. Concrete Inst., Vol. 12, No. 2, p. 104 (1930).

The end of the specimen to be exposed to the water pressure is chipped over its entire surface until the larger pieces of aggregate are exposed. The bottom end is also chipped similarly, except that a ring is left around the outside to provide a smooth seat on the container flange. The ends are wire-brushed and blown clean after chipping.

After a specimen has been prepared, it is placed on the ledge provided in the container in such a position that the space around the perimeter is approximately uniform. The sealing material, either type, is heated to about 300 F. to a water-like consistency and immediately poured in place. About one hour is required to allow the compound to cool and set up. A piece of cotton batten, about $\frac{1}{2}$ in. thick, is placed over the top surface of the specimen to filter out the rust and other large particles which might be present in the water and the container is then assembled. The paraffin-resin type of seal is ready for test at once, but it has been found necessary to apply air pressure at about 50 lb. per sq. in. overnight to the asphalt-sealed specimens to provide proper sealing.

To start a test, the container is attached to the proper unit and the supply system filled with water. After securely tightening all the joints, the air pressure is admitted so that the entire amount is applied within a few minutes. The initial drop in the reservoir gage for this period is disregarded in the computations as it is believed to be caused mainly by the elastic expansion of the system. Inflow readings are taken thereafter frequently during the first day and about once a day for the remainder of the test. A careful inspection is maintained of the bottom surface of the test specimen to determine the exact time of outflow.

The test is continued until a comparatively constant rate of outflow is reached. On completion of the tests, the cylinders sealed with asphalt must be melted out with blow torches. This procedure, though unavoidable, is quite undesirable as the specimens are damaged to an unknown extent by the high temperatures and are rendered unfit for future use. Those sealed with paraffin and resin may be removed by inserting the container in hot water which furnishes sufficient heat to soften up the sealing compound and the specimen slips out easily. This is a considerable advantage from the point of view of cost and leaves the specimens available for retest in the future if required.

COMPARISON OF RESULTS

Since the apparatus as developed for the permeability tests involved measurements of flow, individual test results were reduced to a unit basis by means of a permeability coefficient, K_c. This coefficient was computed for each test from the formula known as d'Arcy's law for viscous flow through small connected voids, which may be expressed as an equation:

$$\frac{Q}{A} = K_c \cdot \frac{H}{L}$$

where Q = rate of discharge in cubic feet per second,

A_c = gross area of the concrete subject to percolation in square feet,

$\frac{H}{L}$ = hydraulic gradient (ratio of fluid head to percolation length), and

K_c = permeability coefficient, or the unit rate of discharge at unit hydraulic gradient, with the dimensions of a velocity, at a temperature of 70 F.

The permeability coefficient was obtained by writing the equation as:

$$K_c = \frac{Q}{A_c} \cdot \frac{L}{H}$$

in which Q is determined from the tangent to the inflow-time curve at a time equal to

250 hr. plus one-half the time to produce outflow. This 250 hr. was chosen as the time at which inflow and outflow rates were approximately equal and substantially uniform for most specimens and was found to be the least time in which the true permeability could be measured. The values thus obtained are 50 to 75 per cent less than those reported by other investigators whose tests were run over an average period of only 24 to 48 hr.

As it was impractical to test specimens so as to have equal curing periods and specimen lengths, it was necessary to apply corrections for these variable factors in order completely to evaluate the coefficients on a comparative basis.

Using data from 12 series of tests, each series consisting of specimens of the same length and mix but tested after different curing periods, a curve, Fig. 4, was derived,

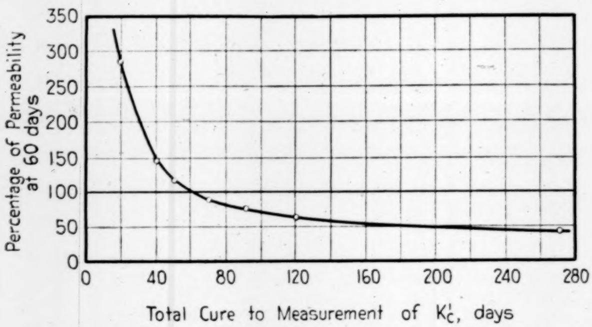

FIG. 4.—Effect of Length of Cure on Permeability.

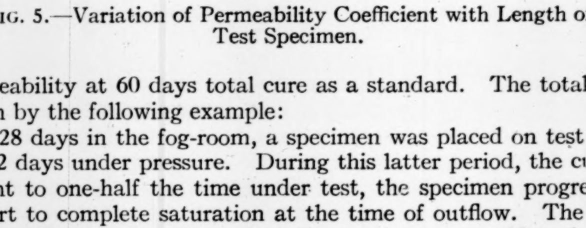

FIG. 5.—Variation of Permeability Coefficient with Length of Test Specimen.

using the permeability at 60 days total cure as a standard. The total cure is determined as shown by the following example:

Cured for 28 days in the fog-room, a specimen was placed on test and produced outflow after 12 days under pressure. During this latter period, the cure is assumed to be equivalent to one-half the time under test, the specimen progressing from no cure at the start to complete saturation at the time of outflow. The flow rate was determined after 250 hr. of outflow when the total cure was 28 + 6 + 10.4 = 44.4 days. For this example, the coefficient calculated for the above rate was divided by 145 per cent (from Fig. 4) to obtain the computed coefficient for 60 days total cure. Inasmuch as most of the tests run were for specimens falling between 40 and 100 total days of cure, the corrections required to bring them to a common basis were not large, and any adjustment or error in the correction curve did not greatly alter the results.

A correction for end effect was necessary because all of the specimens were not of the same length, and the material at either end of a specimen was not believed to be representative of the interior concrete, due to carbonation, water gain, skin formation, and the sealing or caulking caused by the chipping and brushing before the test. To determine this correction, a series of tests was completed using specimens of similar mix, but of various lengths. The permeability coefficients, corrected for cure, were compared and were found to approach constancy as the length increased. The variations of the coefficients indicated a relatively constant end effect, regardless of the length of specimen.

A second series was tested in which normally prepared specimens were compared with other specimens of similar shape and length, but obtained by breaking sections out of longer cylinders, so as to have freshly exposed ends.

Using the data from these two series and assuming a 12-in. length with end effect as standard, Fig. 5 was evolved, indicating an end effect equal to the resistance offered by an additional 6 in. of interior concrete. It can be seen that as the specimen length increases, these end effects become less with respect to unit permeability.

By the application of these curves (time and length corrections), all coefficients were corrected to values that would have been obtained on specimens 12 in. long, with a total cure of 60 days to the time at which K_c was measured. This value of K_c is two-thirds the value of K_c for the interior concrete only.

On the assumption that the permeability of concrete is controlled by the permeability of the paste, a coefficient for paste, K_p, may be determined by means of the formula $K_p = \frac{K_c \times 100}{\text{per cent paste}}$. Similarly, a coefficient for the void space, K_v may be determined by the formula $K_v = \frac{K_c \times 100}{\text{per cent voids}}$. K_v gives the average rate of flow through pores in the concrete.

ACCURACY OF RESULTS

Throughout the test program to date, only two groups of results have contained enough similar specimens to warrant a mathematical study of their accuracy. Even these specimens required corrections for length and for age of test so that the measures of accuracy were influenced by the accuracy of these corrections as well as by the ordinary variations in individual specimens, accuracy of observations, etc.

However, for one group containing 24 specimens made of sand mortar, it was found that the probable error for a single test result is about 34 per cent of the average value. A group of 24 concrete specimens, with 1½-in. maximum size aggregate, indicated a probable error of 36 per cent for a single test. The probable error of a value representing the average of n tests would be about $35/\sqrt{n}$ per cent of the average.

By comparison with test results reported by other investigators, these probable errors indicate good agreement for such a test. The maximum possible errors that could have been caused by erroneous observations are only about one-half the probable error for most specimens, thus indicating that a large part of the variation of results is due to the differences between individual specimens. With such a large probable error, it is evident that variables causing less than a 50-per-cent variation in permeability could not be evaluated by the tests.

LEACHING TESTS

Inasmuch as leaching is an important phase of concrete durability, the majority of the investigations for permeability include a study of cement dissolution due to percolating water. The method developed by the bureau for this purpose is quite simple, yet is thought to provide reasonably accurate results.

Sufficient analyses have been made of the Denver city water so that the content of dissolved solids is well known. It was concluded that a lime analysis of the outflow water from a permeability test, due account being made for the lime content of the water flowing in, would provide a good index of the degree of leaching. It is generally accepted that the free lime in the hydrated cement compounds is dissolved before any of the silicates become affected.

Inasmuch as the greater portion of the lime is dissolved during the early stages of the test, frequent analyses are made. Appropriate samples are taken from known quantities of the outflow water and are analyzed as soon as possible to avoid errors from calcium carbonate precipitations. The analysis is made by the standard alkalinity test of the American Water Works Association, using the proper conversion factors for computing the carbonate, bicarbonate, or hydroxides as CaO. The small errors involved by including the potassium and magnesium salts are negligible and may be overlooked without affecting the results to a considerable degree.

The results may be reported as unit weights of CaO per unit volume of outflow water or, if convenient, as percentages of the computed original lime content. Other investigations have indicated that complete failure of the concrete occurs when half the original lime content has been dissolved. Inasmuch as Denver city water is not particularly corrosive to hydrated cement compounds, it was never possible to reach this point of dissolution.

SUMMARY

The apparatus was satisfactory for the purpose required. With the high-pressure type, water heads as high as 1000 ft. could be applied and concrete specimens 18 by 18 in. could be tested for mixes containing aggregate up to 9 in. maximum. The low-pressure apparatus was suitable for making routine comparisons with only one variable involved, provided that specimens at least 6 in. thick were used.

After extended investigation and painstaking manipulation, a technique was evolved which produced satisfactory tests nine times out of ten. The most important factor was found to be the proper cleaning of the specimen surface for a tight bond to the sealing compound. It is absolutely necessary that this surface be clean and free from any loose or foreign particles.

The mixture of equal parts by weight of commercial paraffin and resin, heated at about 300 F. to a pouring consistency, appeared to be the most satisfactory sealing compound.

The results of permeability tests on specimens of various sizes and ages, tested under various pressures, may be compared satisfactorily by means of a permeability coefficient suitably corrected. The coefficient evaluates the variables of pressure, area, and thickness and may be corrected for end effect and for age at test by means of appropriate factors determined by suitable series of tests previously completed. The use of the coefficient is advantageous in that the results of tests performed by various laboratories may be compared.

Tests made with the apparatus and technique described above provided results of accuracy comparing quite favorably with the results of other investigators. The probable error of a single test is about 35 per cent of the average.

A relatively simple method of determining the amount of leaching by percolating water furnished results of reasonable accuracy with a minimum of expense and time.

Acknowledgments:

Permeability studies of the Bureau of Reclamation were carried forward under the general supervision of Arthur Ruettgers, Engineer in charge of concrete investigations, and B. W. Steele, Designing Engineer on dams. All research and design work is under the direction of J. L. Savage, Chief Designing Engineer. All engineering and construction are under the general direction of R. F. Walter, Chief Engineer, with headquarters in Denver. All activities of the bureau are supervised by John C. Page, Acting Commissioner of Reclamation, Washington, D. C.

APPENDIX II

STUDIES ON RELATION BETWEEN CHARACTERISTICS OF BLAST-FURNACE SLAG AND OTHER COARSE AGGREGATES AND THE PROPERTIES OF RESULTANT CONCRETES

By Fred Hubbard[1]

Specifications for coarse aggregate to be used for concrete purposes sometimes contain requirements which apparently have no bearing upon the concrete-making properties of the materials being specified. This is undoubtedly due to unfamiliarity with the real characteristics of the materials. This is particularly true in the case of blast-furnace slag. The present investigation was undertaken for the purpose of making a rather complete study of the characteristics of blast-furnace slag and determining which of these characteristics affect concrete-making qualities of the material, the study to be made on slag from a sufficient number of sources to make the results conclusive.

The slag used in this investigation was from the same sources of supply, selected in the same manner at the same time, and identical with that used by a section of the Society's Committee C-9 on Concrete and Concrete Aggregates in a study of the "Relation Between the Abrasion Loss of Blast-Furnace Slag and Its Concrete-Making Properties," a report of which was published in 1930.[2] The slags used in the present investigation are the same as those referred to under "New Investigations" in that report. The former investigation of these aggregates was made by five different laboratories and included primarily a study of the relation between the abrasion of the aggregates to the 28- and 90-day strengths of the resulting concrete.

Scope of the Investigation

A thorough investigation was made of the physical and chemical characteristics of blast-furnace slag from sixteen commercial and four non-commercial sources, gravel from six commercial sources and crushed stone from six commercial sources. These materials were all incorporated in concrete for compression, flexure, absorption, wear and durability tests. The same sand and cement was used throughout the series and all concrete was mixed to the same consistency. Yield tests were made on a mixture containing each of the aggregates, and the material required for a cubic yard of concrete was determined.

Compression tests were made on 6 by 12-in. concrete cylinders and flexure tests on 6 by 6 by 40-in. concrete beams. The effect of storage conditions was studied by making up concrete cylinders and beams from ten aggregates for storage in the dry air of the laboratory and out of doors, the results being used as a comparison with concrete made of the same materials stored in the curing room.

Absorption tests and wear tests were made on the concrete beams at 28 days and 3 months. Exposure tests were made on all of the coarse aggregates and also on broken portions of the concrete beams by placing them on the Canton, Ohio, sewage disposal beds where they were subjected to the spray of the sewage and to alternate repeated freezing and thawing during the winter months.

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[1] Director of Research, National Slag Assn., City Bank Building, Youngstown, Ohio.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 545 (1930).

The investigation included the fabrication and testing of 1047 cylinders and 349 beams and making 41 yield tests.

MATERIALS

Cement.—The cement used was Bessemer portland cement manufactured by the Bessemer Limestone and Cement Co., Youngstown, Ohio. It was selected from a bin of commercial material at the plant, sufficient quantity being secured at one time for the entire series of tests. The cement was tested in accordance with A.S.T.M. methods and met all requirements as indicated by the following results:

CHEMICAL ANALYSIS, PER CENT

SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	SO_3	Loss	Total
19.9	4.25	7.03	64.11	1.25	1.67	1.42	99.63

Physical Tests:

Fineness, passing No. 200 sieve	89.0 per cent
Initial set	2 hr. 44 min.
Final set	4 hr. 48 min.
Soundness, boiling test	O. K.

	3 DAYS	7 DAYS	28 DAYS	3 MONTHS
Tensile strength, 1:3 sand briquet, lb. per sq. in.	297	347	414	505
Compressive strength, 1:3 sand, 2 by 2-in. cubes, lb. per sq. in.	2286	2842	4606	4819

Sand.—The sand was from the Akron, Ohio, plant of the Rubber City Sand and Gravel Co. and showed the following characteristics:

Decantation loss	0.4 per cent
Colorimetric test	No. 1
Weight per cubic foot dry, loose	101 lb.
Weight per cubic foot dry, rodded	108 lb.
Specific Gravity	2.65
Voids, dry, loose	38.9 per cent
Voids, dry, rodded	34.6 per cent

The sieve analysis of the sand is as follows:

SIEVE	TOTAL RETAINED, PER CENT
No. 4	1.2
No. 8	10.1
No. 16	25.6
No. 30	45.9
No. 50	91.2
No. 100	99.2
Fineness modulus	2.73

Petrographic analysis showed 3.5 per cent of unsound particles consisting for the most part of soft shale and poorly cemented sandstone.

Coarse Aggregates.—In order to have comparative results on concrete composed of materials other than blast-furnace slag as coarse aggregate, gravel from six sources and crushed stone from six sources were selected (Table I). The materials were selected from sources widely distributed throughout the eastern half of the United States and, with the exception of slags A, B, C and D, represent commercial products which are being marketed for use in concrete construction.

Slags A, B, C and D were hand-picked samples of light-weight material for studying the effect of the use of slag weighing less than 70 lb. per cu. ft.

The coarse aggregates were separated into various sizes ranging from No. 4 to

2-in., square opening sieves, and were then recombined for all of the concrete mixtures in the following proportions:

SIEVE SIZE	TOTAL RETAINED, PER CENT
2-in.	0
1½-in.	27
1-in.	55
¾-in.	69
⅜-in.	90
No. 4	100
Fineness modulus	7.86

The chemical and physical characteristics of the coarse aggregates are as indicated in Tables II to V, inclusive.

TEST METHODS

Tests on Coarse Aggregate:

Unit Weight.—Compact weight per cubic foot determinations were made on samples of each coarse aggregate according to the A.S.T.M. Standard Method of Test for Unit Weight of Aggregate for Concrete (C 29 – 27).[1] Loose weight per cubic foot determinations were made on samples of each coarse aggregate with the material in a loose condition as it was shoveled into the standard container (see Table III).

Abrasion.—Both standard and modified abrasion tests were made on all coarse aggregates, the standard tests being made on uniform size material in accordance with the A.S.T.M. Standard Method of Test for Abrasion of Rock (D 2 – 33),[2] except that a volume of 4000 cu. cm. of material was used instead of 5000 g., and the material was used as it came from the crusher rather than having been broken by hand from large pieces. Modified abrasion tests were made on a graded material in accordance with the A.S.T.M. Tentative Method of Test for Abrasion of Gravel (D 289 – 28 T),[3] this test being made on grading A, which is as follows, on circular opening screens:

Passing a ¾-in. screen, retained on a ½-in. screen	25 per cent
Passing a 1-in. screen, retained on a ¾-in. screen	25 per cent
Passing a 1½-in. screen, retained on a 1-in. screen	25 per cent
Passing a 2-in. screen, retained on a 1½-in. screen	25 per cent

(See Table III)

Specific Gravity.—Specific gravity determinations were made on samples of each coarse aggregate according to the "over-flow" method as described in the Methods of Test for Apparent Specific Gravity and Absorption of Stone and Other Coarse Materials (Tentative Method T-14) of the American Association of State Highway Officials.[4] Determinations were made on 1000-g. samples of pieces approximately 1¼ in. in diameter and on approximately 5000-g. samples of material graded from ½ to 2 in. (see Table III).

Voids.—The percentage of voids was computed on the aggregates in both the loose and compact condition by using the unit weight per cubic foot and the specific gravity results (see Table III).

Soundness.—The sodium sulfate soundness test was made on all coarse aggregates according to the A.A.S.H.O. Method of Test for Soundness of Coarse Aggregate (Tentative Method T-9).[4] This test was continued for twenty cycles with the results as indicated in Table IV.

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 247.

[2] *Ibid.*, p. 944.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 940 (1928); also 1935 Book of A.S.T.M. Tentative Standards, p. 838.

[4] See Tentative Standard Specifications for Highway Materials and Methods of Sampling and Testing of the American Association of State Highway Officials, pp. 109 and 105 (1931); U. S. Department of Agriculture *Bulletin 1216*, September, 1928, pp. 23 and 20.

TABLE I.—SOURCES OF COARSE AGGREGATE.

Non-Commercial Slag			Commercial Slag				Commercial Gravel and Stone	
Aggregate Identification	Method of Handling	Approximate Age When Crushed		Approximate Annual Tonnage	Method of Handling	Approximate Age When Crushed		Approximate Annual Tonnage
A	Hand-picked samples	3 yr.	No. 1	150 000	Modified pit	3 months	No. 17	1 000 000
			No. 2	150 000	Pit	1 week	No. 18	250 000
B	Hand-picked samples	2 months	No. 3	140 000	Pit	1 week	No. 19	450 000
			No. 4	200 000	Modified pit	6 weeks	No. 20	75 000
C	Hand-picked samples	3 yr.	No. 5	150 000	Pit	3 days	No. 21	500 000
			No. 6	500 000	Modified pit	2 months	No. 22	396 000
D	Hand-picked samples	6 months	No. 7	400 000	Modified pit	6 months	No. 23	400 000
			No. 8	200 000	Pit	3 days	No. 24	350 000
			No. 9	1 000 000	Modified pit	2 months	No. 25	700 000
			No. 10	100 000	Modified pit	2 months	No. 26	1 000 000
			No. 11	600 000	Bank	15 yr.	No. 27	750 000
			No. 12	200 000	Modified pit	6 weeks	No. 28	2 000 000
			No. 13	100 000	Bank	60 yr.		
			No. 14	300 000	Bank	2 yr.		
			No. 15	65 000	Pit	1 week		
			No. 16	200 000	Modified pit	6 weeks		

TABLE II.—CHEMICAL ANALYSIS OF COARSE AGGREGATE.

Aggregate	SiO_2, per cent	Al_2O_3, per cent	Fe_2O_3, per cent	MnO, per cent	CaO, per cent	MgO, per cent	S, per cent
Non-commercial slag:[a]							
A	33.52	14.29	0.75	0.49	36.58	9.98	1.48
B	32.58	12.50	0.76	0.28	41.39	10.30	1.74
C	31.61	10.00	0.85	0.48	36.56	14.63	1.25
D	33.43	15.38	2.42	0.37	43.56	1.84	1.30
Commercial slag:							
No. 1	33.35	12.78	0.71	1.32	39 28	10.37	1.69
No. 2	34.68	14.02	0.90	0.72	40 99	7.04	1.55
No. 3	38.49	12.40	0.75	0.20	37 85	9.00	1.05
No. 4	39.63	13.86	0.63	0.26	37 50	7.94	0.83
No. 5	37.06	12.82	0.56	0.26	42 17	6.68	0.57
No. 6	36.99	10.40	0.75	0.25	44 50	5.45	1.05
No. 7	35.63	14.88	0.75	0.77	44.28	3.72	0.68
No. 8	36.88	13.07	0.69	0.27	44.32	3.52	0.83
No. 9	37.38	10.81	1.01	0.31	42.38	5.86	1.09
No. 10	34.79	17.54	0.63	0.39	43.26	3.13	0.55
No. 11	36.01	13.87	0.88	0.44	42.23	5.71	1.48
No. 12	39.79	13.96	0.63	0.36	37.18	7.86	0.97
No. 13	40.67	10.30	0.83	0.26	26.51	19.86	0.75
No. 14	38.11	12.33	0.72	0.26	42 09	6.15	0.88
No. 15	43.02	8.60	0.70	0.12	40 88	6.37	1.19
No. 16	40.59	13.11	0.50	0.37	37 18	7.95	0.92
Average	37.82	12.79	0.73	0.41	40 16	7.28	1.00
Commercial gravel and stone:							
No. 17	85.52	7.70	5.42	....	0.76	.....	....
No. 18	95.60	1.64	2.16	....	0.57	.....	....
No. 19	58.88	6.53	4.07	....	15.08	1.39	....
No. 20	72.60	14.74	2.24	....	1.76	0.98	....
No. 21	87.76	6.96	4.60	....	0.76	.....	....
No. 22	1.58	1.22	0.68	....	40 48	13.52	....
No. 23	9.66	1.72	0.86	....	27.45	18.10	....
No. 24	4.48	1.03	0.59	....	52.60	1.22	....
No. 25	3.50	1.85	1.47	....	52.01	0.80	....
No. 26	12.08	4.30	2.28	....	25.27	17.38	....
No. 27	50.28	7.12	3.60	....	15 52	5.79	....
No. 28	52.16	16.24	10.84	....	11.16	6.06	....

[a] Since these are non-commercial materials, the results are not used in the average.

Exposure Tests.—Exposure tests were made on all coarse aggregates and concrete. In the case of the coarse aggregates fifty pieces of each aggregate ranging in size from 1½ to 2 in. were selected and placed in a wire container of such shape that the material was held in one layer a single piece in depth. In the case of the concrete, broken pieces of beams used in the flexure tests were selected. These specimens were approximately 6 by 6 by 11 in. in size, one specimen being selected from each concrete combination.

TABLE III.—UNIT WEIGHT, ABRASION, SPECIFIC GRAVITY, ABSORPTION, VOIDS OF COARSE AGGREGATE.

Aggregate	Unit Weight, lb. per cu. ft.		Abrasion Loss, per cent		Specific Gravity	Total Absorption		Absorption During 30 min.		Voids, per cent	
	Loose	Compact	Standard	Modified		By Weight, per cent	Solid, lb. per cu. ft.	By Weight, per cent	Solid, lb. per cu. ft.	Loose	Compact
Non-commercial slag:[a]											
A	52.8	62.8	27.2	26.6	1.57	10.8	10.6	6.0	5.9	46.1	35.9
B	57.3	66.8	15.6	31.5	1.74	8.4	9.1	3.8	4.1	47.0	38.3
C	57.6	67.3	23.1	28.6	1.74	9.1	9.8	5.5	6.0	47.0	38.0
D	59.6	69.7	16.5	22.4	1.94	6.2	7.4	2.9	3.5	50.8	42.3
Commercial slag:											
No. 1	65.5	75.0	17.3	21.2	2.08	5.7	7.4	3.2	4.1	49.6	42.2
No. 2	69.5	79.2	14.4	26.3	2.06	4.7	6.1	1.8	2.3	46.0	38.5
No. 3	69.8	79.2	15.5	23.7	2.14	4.3	5.7	2.1	2.8	47.7	40.6
No. 4	69.4	80.0	18.6	26.3	2.00	3.7	4.6	2.0	2.5	44.3	35.8
No. 5	71.5	80.5	15.0	30.0	2.21	3.3	4.6	2.5	3.4	48.2	41.7
No. 6	71.4	82.6	7.5	21.0	2.23	3.2	4.5	2.1	2.9	48.7	40.7
No. 7	72.4	82.9	8.9	17.7	2.21	3.4	4.7	1.7	2.3	47.5	39.8
No. 8	73.7	84.2	8.2	20.6	2.26	3.0	4.3	1.6	2.3	47.8	40.4
No. 9	73.4	84.4	10.3	20.9	2.24	3.5	5.0	2.0	2.8	47.6	39.7
No. 10	78.9	90.1	8.9	16.9	2.30	2.4	3.4	1.4	2.0	44.7	37.1
No. 11	78.5	90.5	8.9	20.1	2.33	3.5	5.0	1.7	2.5	45.9	47.7
No. 12	85.6	95.6	10.5	19.3	2.42	1.6	2.4	0.8	1.3	43.2	36.5
No. 13	83.2	96.2	6.1	17.7	2.57	1.9	3.0	0.7	1.1	48.1	40.0
No. 14	88.2	98.4	9.3	20.6	2.62	1.0	1.6	0.8	1.3	45.9	39.6
No. 15	88.7	100.7	4.8	16.7	2.64	0.8	1.2	0.6	1.0	46.0	38.7
No. 16	88.5	101.3	6.3	19.8	2.56	0.8	1.2	0.4	0.6	44.4	36.3
Average	76.7	87.5	10.6	21.2	2.30	2.9	4.0	1.6	2.2	46.7	39.0
Commercial gravel and stone:											
No. 17	100.0	108.4	2.9	12.5	2.50	1.5	2.4	1.0	1.6	35.9	30.4
No. 18	102.8	112.3	1.2	19.9	2.55	0.8	1.3	0.5	0.8	35.2	29.2
No. 19	99.5	108.5	0.7	7.1	2.57	1.3	2.1	0.5	0.8	37.8	32.2
No. 20	87.0	101.0	2.7	32.6	2.60	0.6	0.9	0.6	1.0	46.4	37.8
No. 21	104.2	113.2	3.3	22.3	2.60	0.4	1.2	0.3	0.5	35.6	30.0
No. 22	90.6	102.5	3.2	19.3	2.63	3.1	5.0	1.3	2.1	44.7	37.6
No. 23	85.7	100.3	5.0	17.0	2.64	2.2	3.5	1.2	2.0	47.9	39.1
No. 24	91.5	106.8	2.9	18.2	2.67	0.8	1.3	0.3	0.5	45.1	35.9
No. 25	90.0	103.6	4.3	15.9	2.70	0.5	0.8	0.1	0.2	46.5	38.4
No. 26	101.9	112.0	2.1	9.2	2.71	1.1	1.9	1.2	2.0	39.8	33.8
No. 27	102.5	110.9	1.1	6.6	2.74	0.7	1.3	0.8	1.4	40.1	35.2
No. 28	96.0	113.0	3.1	9.8	2.92	0.5	0.8	0.1	0.2	47.2	37.8
Average	96.0	107.7	2.7	15.8	2.65	1.1	1.9	0.6	1.1	41.8	34.8

[a] Since these are non-commercial materials, the results are not used in average. Data from this table appear in Figs. 2, 6, 7, 8, 9 and 10.

These samples, both aggregate and concrete, were exposed on the sprinkling filters of the Canton, Ohio, sewage-disposal beds, being arranged in a circle around the spray nozzle in such a way as to get the maximum effect of alternate wetting and drying and of the additional freezing and thawing during the winter months. It is intended to continue the observation of these materials for a number of years. Results of the exposure tests are given in Table V.

Tests on Fine Aggregate:

Decantation loss was determined according to the A.S.T.M. Standard Method of Decantation Test for Sand and Other Fine Aggregates (D 136 – 28).[1] Colorimetric tests were made according to the A.S.T.M. Standard Method of Test for Organic Impurities in Sands for Concrete (C 40 – 33).[2]

Compact weight per cubic foot determinations were made according to the A.S.T.M. Standard Method of Test for Unit Weight of Aggregate for Concrete (C 29 – 27).[3] Loose weight determinations were made on the material placed in the standard container in a dry loose condition.

TABLE IV.—SOUNDNESS OF COARSE AGGREGATE.

Expressed in per cent of sound pieces after 5, 10, 15 and 20 cycles of sodium sulfate.

Aggregate	5 Cycles	10 Cycles	15 Cycles	20 Cycles
Non-commercial slag:				
A	100	100	80	80
B	100	100	95	95
C	100	100	100	100
D	100	100	100	100
Commercial slag:				
No. 1	100	100	100	100
No. 2	100	100	100	100
No. 3	100	100	100	100
No. 4	100	100	100	100
No. 5	100	100	100	100
No. 6	100	100	100	100
No. 7	100	90	90	90
No. 8	100	100	100	100
No. 9	100	100	100	100
No. 10	100	100	90	90
No. 11	100	100	100	100
No. 12	100	100	100	100
No. 13	100	100	100	100
No. 14	100	100	100	100
No. 15	100	100	100	100
No. 16	100	100	100	95
Commercial gravel and stone:				
No. 17	100	100	95	95
No. 18	100	100	95	90
No. 19	100	100	95	95
No. 20	100	100	100	100
No. 21	100	100	100	100
No. 22	100	90	85	80
No. 23	90	80	70	60
No. 24	100	100	95	95
No. 25	100	85	80	75
No. 26	100	100	100	100
No. 27	100	100	100	100
No. 28	100	100	100	100

Specific gravity tests were made by the pycnometer method as described in the A.A.S.H.O. Method of Test for Apparent Specific Gravity and Absorption or Free Moisture Content of Sand, Gravel, Stone or Other Nonbituminous Highway Materials (Tentative Method T-15).[4] Void determinations were made according to the A.S.T.M. Standard Method of Test for Determination of Voids in Fine Aggregate for Concrete (C 30 – 22).[5]

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 951.

[2] *Ibid.*, p. 236.

[3] *Ibid.*, p. 247.

[4] See Tentative Standard Specifications for Highway Materials and Methods of Sampling and Testing of the American Association of State Highway Officials, p. 110 (1931); U. S. Department of Agriculture *Bulletin 1216*, September, 1928, p. 23.

[5] 1933 Book of A.S.T.M. Standards, Part II, p. 249.

Tests on Concrete:

Concrete Yield Tests.—Yield tests were made on concretes of each coarse aggregate and the materials required for a cubic yard of hardened concrete computed. These tests were made by actually mixing a quantity of concrete in the proportions and of the consistency actually used for making up the concrete for strength tests. The concrete was sufficient to nearly fill a 12 by 24-in. cylindrical steel mold which rested upon a machined steel plate, the molds having all inside surfaces machined. After the concrete was hardened, accurate measurements were made of the actual volume and from this the quantities of material necessary for a cubic yard of finished concrete were computed, the results being as indicated in Tables VI, VII, XIV and XV.

TABLE V.—SOUNDNESS OF COARSE AGGREGATE AS INDICATED BY EXPOSURE TESTS ON CANTON SEWAGE-DISPOSAL BEDS.

Material placed on beds March 5, 1930.

Aggregate	Number of Pieces	Weight, g.	Loss in Weight, per cent		
			Exposed 571 days	Exposed 837 days	Exposed 1777 days
Non-commercial slag:					
A	50	4015	10.9	11.8	26.5
B	50	4090	0	1.2	6.8
C	50	3220	1.9	2.5	11.5
D	50	4620	0	0.8	8.8
Commercial slag:					
No. 1	50	5717	0.4	0.4	3.1
No. 2	50	5165	0	0.3	0.4
No. 3	50	5615	2.7	2.7	2.7
No. 4	50	4960	0	0	3.6
No. 5[a]	....	....	....	....	....
No. 6	50	5020	0	0	0
No. 7	50	5550	0	0	0.7
No. 8	50	6067	2.0	2.3	3.2
No. 9	50	5175	0	0	0
No. 10	50	6343	0	0	2.5
No. 11	50	5270	2.6	3.7	5.0
No. 12	50	6562	0	0	0
No. 13	50	6297	0	0	0
No. 14	50	5890	1.4	1.9	3.0
No. 15	50	6060	0	0	0
No. 16	50	6963	0	0	2.8
Commercial gravel and stone:					
No. 17	50	6594	0	0	0
No. 18	50	6694	0	0	0
No. 19	50	6895	0	0	0
No. 20	50	5765	1.2	1.2	3.5
No. 21	50	6869	0	0	0
No. 22	50	6032	3.5	3.5	6.7
No. 23	50	5080	0	2.0	15.0
No. 24	50	6050	3.7	3.7	4.1
No. 25	50	6400	0	0	3.8
No. 26	50	6701	1.9	2.3	6.2
No. 27	50	6917	1.3	1.3	3.5
No. 28	50	6594	0	0	0

[a] Determinations not made.

Concrete Strength Tests.—In the previously reported investigation of these aggregates each of the five cooperating laboratories used sands which were readily available in the districts where the laboratories were located. Difference in the grading of the sands would theoretically affect the percentages required to a considerable extent and Committee C-9 therefore arbitrarily set the proportion of fine to coarse on a 40 to 60 dry-rodded basis, or in other words, the mixes were all to be made 1:2:3 by dry-rodded volume.[1]

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 545 (1930).

Yield tests on the slag concrete indicated that this mix contained 6.3 sacks of cement per cubic yard. All concrete using crushed material as the coarse aggregate therefore was mixed in the proportion of 40 per cent sand and 60 per cent coarse aggregate. All concrete using rounded gravel as the coarse aggregate was mixed in the proportion of 35 per cent sand and 65 per cent coarse aggregate. All proportioning was done on a dry-rodded volume basis.

TABLE VI.—YIELD TESTS OF CONCRETE.

Mix 6.3 sacks per cubic yard.

Mixed by dry rodded volume, slag concrete 1:2:3. Stone concrete 1:1.96:2.94; gravel concrete 1:1.67:3.09.

Aggregate	Slump, in.	Flow	Net Water-Cement Ratio, $\frac{w}{c}$	Quantities per cubic yard of Concrete						Mortar-Void Ratio[c]	Weight of Concrete, lb. per cu. ft.
				Cement		Sand		Coarse Aggregate			
				Actual	Computed	cu. ft.	lb.	cu. ft.	lb.		
Non-commercial slag:[a]											
A	2.25	174	0.75	6.3	6.0	12.6	1363	19.0	1191	2.35	126.0
B	2.00	170	0.75	6.4	6.2	12.9	1389	19.3	1288	2.21	129.0
C	2.00	170	0.75	6.3	6.1	12.6	1360	18.9	1270	2.23	129.0
D	2.00	170	0.75	6.5	6.3	13.1	1390	19.7	1371	1.98	132.7
Commercial slag:											
No. 1	2.25	172	0.75	6.3	6.3	12.7	1375	19.1	1429	2.00	134.7
No. 2	2.50	172	0.75	6.4	6.1	12.8	1385	19.3	1528	2.19	139.3
No. 3	2.25	176	0.75	6.4	6.2	12.8	1382	19.2	1523	2.09	138.0
No. 4	2.50	172	0.75	6.3	6.1	12.5	1351	18.8	1557	2.37	135.5
No. 5	1.75	168	0.75	6.4	6.3	12.8	1385	19.3	1550	2.03	138.0
No. 6	2.75	173	0.75	6.4	6.2	12.7	1370	19.1	1570	2.09	138.0
No. 7	1.50	178	0.75	6.3	6.2	12.6	1359	18.9	1566	2.13	138.5
No. 8	2.25	175	0.75	6.4	6.2	12.8	1379	19.2	1616	2.10	140.6
No. 9	2.75	184	0.75	6.3	6.2	12.6	1363	19.0	1617	2.13	140.0
No. 10	2.25	182	0.75	6.3	6.1	12.7	1367	19.0	1710	2.28	144.0
No. 11	2.50	174	0.75	6.3	6.1	12.5	1348	18.8	1700	2.25	142.2
No. 12	2.00	172	0.75	6.3	6.1	12.5	1348	18.8	1795	2.33	146.5
No. 13	2.00	171	0.75	6.3	6.2	12.6	1363	19.0	1823	2.11	147.7
No. 14	2.00	175	0.75	6.1	6.2	12.3	1330	18.5	1818	2.13	146.2
No. 15	2.25	175	0.75	6.3	6.2	12.5	1351	18.8	1893	2.20	150.0
No. 16	2.50	175	0.75	6.2	6.1	12.4	1333	18.5	1881	2.35	147.2
Average	2.25	174	0.75	6.3	6.2	12.6	1362	18.9	1661	2.18	141.6
Commercial gravel and stone:											
No. 17	1.75	170	0.70	6.2	6.1	10.4	1120	19.1	2071	2.44	147.5
No. 18	2.25	174	0.70	6.2	6.0	10.4	1126	19.2	2159	2.53	148.0
No. 19	2.25	174	0.70	6.3	6.2	10.4	1129	19.3	2094	2.31	148.6
No. 20	2.00	178	0.75	6.3	6.2	12.3	1325	18.4	1862	2.28	147.8
No. 21	2.25	172	0.70	6.2	6.1	10.4	1120	19.1	2164	2.47	150.0
No. 22	2.25	174	0.75	6.3	6.2	12.3	1332	18.5	1899	2.28	149.3
No. 23	2.25	176	0.75	6.3	6.3	12.3	1325	18.4	1849	2.20	146.3
No. 24	2.00	170	0.75	6.1	6.1	12.0	1296	18.0	1927	2.38	150.0
No. 25	2.00	174	0.75	6.3	6.2	12.3	1325	18.4	1907	2.24	147.8
No. 26	2.50	177	0.70	6.2	6.2	10.4	1120	19.1	2142	2.19	149.5
No. 27	2.25	175	0.70	6.3	6.3	10.5	1138	19.4	2156	2.11	151.5
No. 28	2.00	174	0.75	6.2	6.2	12.2	1318	18.3	2070	2.26	155.8
Average	2.15	174	0.72	6.2	6.2	11.3	1223	18.8	2027	2.28	149.5

[a] Since there are non-commercial materials, the results are not used in average.

[b] Computed from the absolute volumes of the materials.

[c] Obtained by dividing the sum of the absolute volumes of cement plus sand plus water by the volume of voids in the compact coarse aggregate.

Concrete mixtures containing each aggregate were tested in such proportions as to use 6.3 sacks of cement per cubic yard of finished concrete, and mixtures containing nine slags were also tested in such proportions as to use 5.4 sacks of cement per cubic yard of finished concrete. All concrete was mixed to the same consistency as indicated by a slump of approximately $2\frac{1}{4}$ in. and a flow of 175. To meet these conditions the dry-rodded mixes and water-cement ratios were as follows:

	MIX	WATER-CEMENT RATIO
6.3-sack mix for slags	1:2:3	0.75
6.3-sack mix for stones	1:1.96:2.94	0.75
6.3-sack mix for gravels	1:1.67:3.09	0.70
5.4-sack mix for slags	1:2.4:3.6	0.93

TABLE VII.—PROPORTIONS OF AGGREGATES FOR CONCRETE BY ABSOLUTE VOLUME IN CUBIC FEET PER SACK OF CEMENT.

Computed from unit weight and specific gravity of materials used.

Aggregate	Cement	Sand	Slag	Water	Total	Cement per cu. yd., sacks
Non-commercial slag:						
A	0.490	1.307	1.925	0.750	4.472	6.04
B	0.490	1.307	1.847	0.750	4.394	6.14
C	0.490	1.307	1.861	0.750	4.408	6.13
D	0.490	1.307	1.729	0.750	4.276	6.31
Commercial slag:						
No. 1	0.490	1.307	1.735	0.750	4.282	6.31
No. 2	0.490	1.307	1.850	0.750	4.397	6.14
No. 3	0.490	1.307	1.781	0.750	4.328	6.24
No. 4	0.490	1.307	1.925	0.750	4.472	6.04
No. 5	0.490	1.307	1.753	0.750	4.300	6.28
No. 6	0.490	1.307	1.782	0.750	4.329	6.24
No. 7	0.490	1.307	1.805	0.750	4.352	6.20
No. 8	0.490	1.307	1.793	0.750	4.340	6.22
No. 9	0.490	1.307	1.813	0.750	4.360	6.19
No. 10	0.490	1.307	1.885	0.750	4.432	6.09
No. 11	0.490	1.307	1.869	0.750	4.416	6.11
No. 12	0.490	1.307	1.901	0.750	4.448	6.07
No. 13	0.490	1.307	1.801	0.750	4.348	6.21
No. 14	0.490	1.307	1.807	0.750	4.354	6.20
No. 15	0.490	1.307	1.835	0.750	4.382	6.16
No. 16	0.490	1.307	1.904	0.750	4.451	6.07
Average	0.490	1.307	1.830	0.750	4.377	6.17
	Cement	Sand	Stone, Gravel	Water	Total	Cement per cu. yd., sacks
Commercial stone and gravel:						
No. 17	0.490	1.092	2.149	0.700	4.431	6.09
No. 18	0.490	1.092	2.181	0.700	4.463	6.05
No. 19	0.490	1.092	2.092	0.700	4.374	6.17
No. 20	0.490	1.281	1.832	0.750	4.353	6.20
No. 21	0.490	1.092	2.158	0.700	4.440	6.08
No. 22	0.490	1.281	1.838	0.750	4.359	6.19
No. 23	0.490	1.281	1.791	0.750	4.312	6.26
No. 24	0.490	1.281	1.886	0.750	4.407	6.13
No. 25	0.490	1.281	1.809	0.750	4.330	6.24
No. 26	0.490	1.092	2.048	0.700	4.330	6.24
No. 27	0.490	1.092	2.006	0.700	4.288	6.30
No. 28	0.490	1.281	1.825	0.750	4.346	6.21
Average	0.490	1.187	1.965	0.725	4.367	6.18

All materials were used in a room-dry condition. The coarse aggregate was screened into the sizes indicated and the various sizes recombined according to the prescribed percentages for each mix. The concrete was mixed in a batch mixer in batches of approximately $3\frac{1}{2}$ cu. ft. of fine and coarse aggregate measured separately. The sand and cement were first mixed dry for 2 min., then the coarse aggregate was added and mixed dry for an additional 2 min. At this time the water was added and the entire batch mixed for 5 min., after which the slump and flow tests were made and the concrete placed in the cylinders and beams.

The batches were of sufficient quantity of concrete to cast twelve 6 by 12-in. cylinders and four 6 by 6 by 40-in. beams from two batches. Standard A.S.T.M. procedure was followed in molding the cylinders and beams. Twelve cylinders were cast from a single batch with a small quantity of concrete remaining which was placed in the beam forms. The next batch was used for casting the remaining portion of the four beams.

This method of mixing and placing the concrete gave very uniform results. A test run on twenty-four cylinders at 28 days of age showed a mean variation of 2 per cent and a maximum variation of 6.8 per cent on individual cylinders. In groups of three cylinders the mean variation was 1.6 per cent and the maximum variation, 2.7 per cent.

TABLE VIII.—COMPRESSIVE STRENGTH OF CONCRETE, MOIST STORAGE.

Mix 6.3 sacks per cubic yard.

Aggregate	7 days	14 days	28 days	2 months	3 months	6 months	1 yr.	2 yr.	5 yr.
Non-commercial slag:[a]									
A	3010	....	4100	....	4540	....	4510	....	4720
B	3380	....	4290	....	5230	....	5110	....	5780
C	3490	4180	4260	....	4600	4720	5390	....	5290
D	3370	3880	4280	....	5530	5750	5760	....	6240
Commercial slag:									
No. 1	3770	4430	4950	....	5340	6280	6600	....	6440
No. 2	3790	4720	4690	5680	5540	6430	6230	6480	6870
No. 3	3700	....	5280	....	5230	....	6330	....	6770
No. 4	3290	....	4930	....	6530	....	6290	....	6070
No. 5	3500	....	4800	....	5350	....	6170	....	6690
No. 6	3380	....	4990	....	5730	....	6260	....	6960
No. 7	3570	4040	4550	5410	5850	6320	6030	5780	5700
No. 8	3430	4310	5270	5490	5830	6240	6710	6900	7140
No. 9	3840	....	5100	....	5980	....	6520	....	7210
No. 10	3310	....	4970	....	5370	....	6010	....	6790
No. 11	3910	4600	4910	5850	6230	6080	6390	6250	6790
No. 12	3590	4400	5300	5740	6340	6200	6590	6200	7260
No. 13	3690	....	5350	....	6090	....	6630	....	6780
No. 14	3610	4360	5420	5490	6060	6730	7260	7140	7290
No. 15	3580	....	5350	....	5950	....	6520	....	6580
No. 16	3480	....	5280	....	6610	....	6880	....	6950
Average	3590	4410	5070	5610	5880	6330	6460	6460	6770
Commercial gravel and stone:									
No. 17	3450	3710	4340	4850	4960	5250	5230	5040	6100
No. 18	3600	4140	4790	4980	5660	5610	5820	6000	6300
No. 19	3810	....	4760	....	5850	....	6280	....	6740
No. 20	3950	....	5110	....	6030	....	6620	....	6840
No. 21	3290	....	4250	....	5150	....	5570	....	5590
No. 22	4030	4340	5070	5750	6250	6810	7420	7550	7830
No. 23	3620	....	5140	....	6040	....	7000	....	6930
No. 24	3960	4630	5160	5450	6070	6080	6870	6810	6410
No. 25	4180	4260	4620	5460	5630	5630	5720	5980	6460
No. 26	3980	4170	4690	5240	5590	5790	6230	6630	6080
No. 27	3560	....	4730	....	5220	....	5650	....	6180
No. 28	3560	....	5110	....	6080	....	6560	....	6970
Average	3750	4210	4810	5290	5710	5860	6250	6340	6540
Grand average	3660	4320	4960	5450	5800	6110	6370	6400	6670

[a] Since these are non-commercial materials, the results are not used in the average.

Data from this table appear in Figs. 2, 3, 4 and 6.

A test run on eight beams, representing twenty-four breaks, showed a mean variation of 3.5 per cent and a maximum variation of 8.3 per cent for individual breaks, and a mean variation of 3.0 per cent and a maximum variation of 4.3 per cent for each individual beam, each beam giving three breaks.

All moist storage specimens were placed in a moist curing room 24 hr. after molding and maintained at approximately 70 F. until tested. Dry storage specimens were placed in the curing room for 14 days, after which they were removed and stored in the dry air of the laboratory. Outside storage specimens were placed in the curing room for 14 days, after which they were placed outside on the ground, the beams being laid flat and the cylinders placed on end.

All specimens of concrete for both compression and flexure tests were tested wet, according to standard practice. This holds true for both dry and outside storage specimens as well as for the moist storage specimens. The dry and outside storage specimens were immersed in water for 48 hr. before testing in order to bring them to approximately the same moisture condition as the moist storage specimens.

Compression tests on the concrete cylinders were made on a 300,000-lb. Olsen compression machine and the flexure tests were made on a cantilever loading machine with dynamometer, this machine being the same type as that used by the Ohio Highway Department (see Fig. 1). Results of strength tests are as shown in Tables VIII, IX, X, XI, XII, XVI, XVII, XVIII and XX.

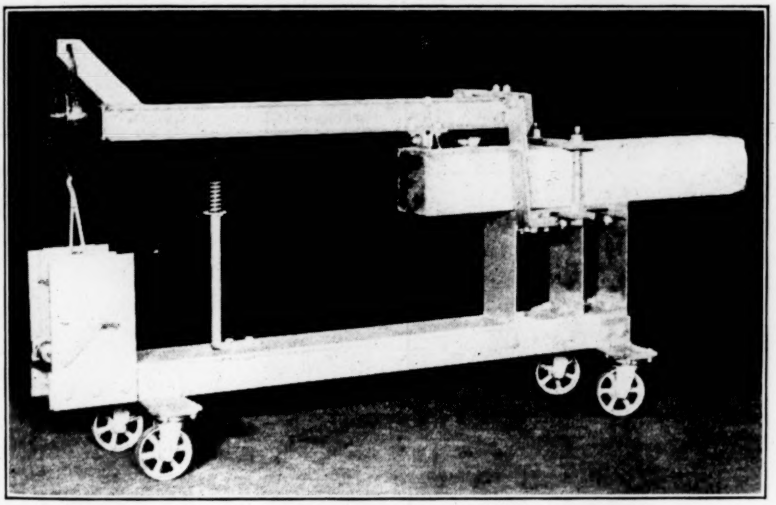

FIG. 1.—Cantilever Loading Machine for Flexure Testing.

Concrete Absorption Tests.—Absorption tests of concrete were made by immersing broken pieces of the beams, approximately 6 by 6 by 11 in. in size, in water for 48 hr., after which they were dried to constant weight in an oven maintained at 212 to 225 F. (100 to 105 C.). The percentage of absorption was calculated from the loss of weight on drying, the percentage being based on the dry weight. See Tables XIII, XIV and XX.

Concrete Wear Tests.—Wear tests were made on the top surface of broken pieces of beams. The concrete wear testing apparatus was the same as that used by the Columbus Testing Laboratory for testing concrete floor surfaces. It consists of a mechanically driven arm on the end of which is fastened a guide on which is placed a steel block that is used as the wearing device. Standard Ottawa sand was used as an abrasive under the block, which was moved back and forth over the concrete with a combined rocking and sliding motion. Wear results are given as depth of wear in inches after a 7-hr. run of the machine. The wear results obtained by this apparatus are not considered entirely satisfactory, as a few grains of large sand particles near the

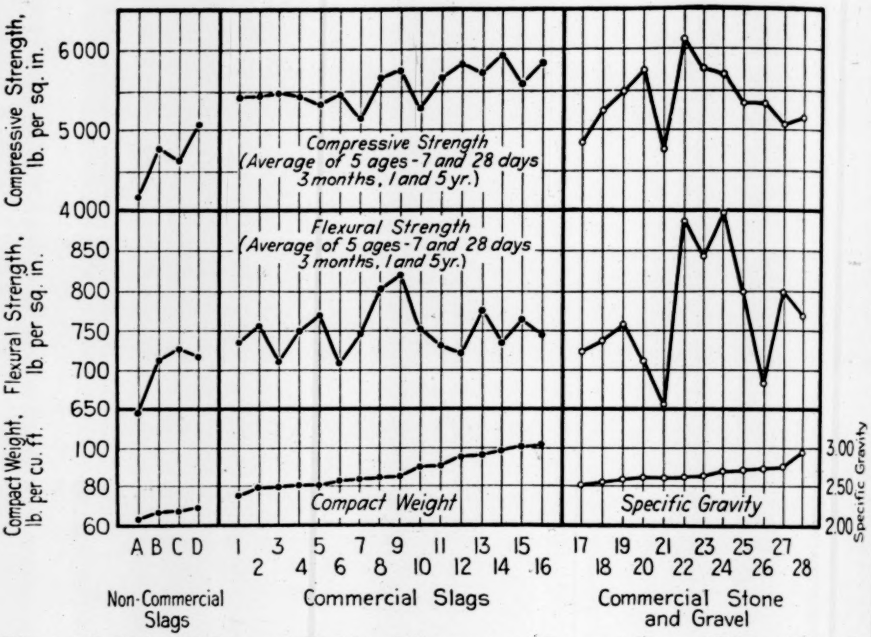

FIG. 2.—Relation of Compact Weight of Aggregate to Compressive and Flexural Strengths of Concrete.

32 aggregates, equal cement content (6.3 sacks per cu. yd.), moist storage. Data from Tables III, VIII and IX.

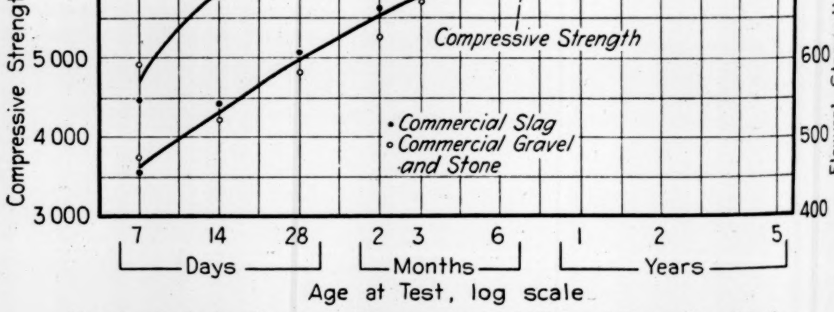

FIG. 3.—Relative Change in Compressive and Flexural Strengths with Age.

28 commercial aggregates, equal cement content (6.3 sacks per cu. yd.), moist storage. Data from Tables VIII and IX.

surface of the concrete materially affect the test. The results of this method of test are more representative of the wear on the mortar than on the coarse aggregate. (See Table XIII.)

DISCUSSION OF TEST DATA

Detailed results of the tests are shown in Tables I to XX, inclusive. Certain comparisons are also shown graphically in Figs. 2 to 11, inclusive.

TABLE IX.—FLEXURAL STRENGTH OF CONCRETE, MOIST STORAGE.

Mix 6.3 sacks per cubic yard.

Aggregate	7 days	14 days	28 days	2 months	3 months	6 months	1 yr.	2 yr.	5 yr.
Non-commercial slag:[a]									
A	540	...	665	...	650	...	730	...	630
B	515	...	640	...	710	...	855	...	835
C	590	620	640	...	750	830	850	...	815
D	620	640	665	...	715	760	815	...	770
Commercial slag:									
No. 1	605	740	690	...	675	795	830	...	875
No. 2	500	690	705	790	780	775	910	865	885
No. 3	460	...	705	...	725	...	800	...	860
No. 4	615	...	730	...	715	...	820	...	865
No. 5	540	...	740	...	815	...	850	...	885
No. 6	440	...	710	...	670	...	810	...	915
No. 7	530	725	705	710	740	795	850	855	895
No. 8	570	640	805	695	820	845	785	915	1035
No. 9	630	...	840	...	800	...	860	...	980
No. 10	540	...	795	...	770	...	795	...	855
No. 11	565	645	665	750	735	840	850	845	850
No. 12	540	705	635	745	655	770	850	820	940
No. 13	640	...	665	...	790	...	865	...	915
No. 14	565	625	680	690	740	810	845	915	850
No. 15	495	...	710	...	770	...	850	...	990
No. 16	560	...	720	...	705	...	855	...	890
Average	550	680	720	730	745	805	840	870	905
Commercial gravel and stone:									
No. 17	570	620	720	725	780	705	725	855	835
No. 18	525	670	690	680	750	825	815	910	915
No. 19	605	...	690	...	770	...	840	...	885
No. 20	550	...	680	...	715	...	810	...	825
No. 21	485	...	605	...	665	...	725	...	790
No. 22	680	730	830	940	945	905	940	990	1045
No. 23	640	...	740	...	790	...	1040	...	1005
No. 24	660	675	890	830	960	855	970	940	1010
No. 25	660	725	720	800	830	795	905	905	880
No. 26	615	735	785	880	965	970	965	1000	985
No. 27	590	...	770	...	815	...	865	...	950
No. 28	580	...	765	...	785	...	840	...	870
Average	595	690	740	810	815	840	870	935	915
Grand average	570	685	730	770	770	820	850	900	910

[a] Since these are non-commercial materials, the results are not used in the average.

Data from this table appear in Figs. 2, 3, 4 and 6.

Figure 2 shows the relation between the compact unit weight of the coarse aggregate and the compressive and flexural strengths of the resulting concrete under moist storage conditions. Concrete was tested at the following ages: 7 and 28 days, 3 months, 1 and 5 yr. The results as shown on the figure represent the average of the strengths developed by the concrete at all ages, each point representing the average of fifteen cylinders or fifteen beam breaks tested at five different age intervals.

The compressive strength of the slag concrete increases slightly as the unit weight increases. This increase in strength with weight is quite pronounced in non-commercial slags weighing less than 70 lb. per cu. ft., but much less in slags meeting a minimum requirement of 70 lb. per cu. ft. as called for by most specifications. It will be noted that the unit weight of the slags studied varied from 62.8 lb. for slag A to 101.3 lb. for slag No. 16.

The flexural strength of the slag concrete is apparently not affected by the unit weight of the commercial slag aggregate. Slag A which shows a relatively low strength is an especially light-weight slag, not meeting A.S.T.M. requirements of 70 lb. per cu. ft. The specific gravity of the stone and gravel aggregates apparently does not affect either the compressive or flexural strength of the resulting concrete. The sixteen commercial slags tested show more uniformity in both compressive and flexural strength than do the twelve stone and gravel aggregates.

TABLE X.—RELATIVE VALUES OF COMPRESSIVE AND FLEXURAL STRENGTHS OF CONCRETE

Moist storage, mix 6.3 sacks per cubic yard.

Aggregate	Compression					Flexure				
	Age at Test					Age at Test				
	7 days	28 days	3 months	1 yr.	5 yr.	7 days	28 days	3 months	1 yr.	5 yr.
Average, lb. per sq. in.	3660	4960	5800	6370	6670	570	730	770	850	910
Non-commercial slag:[a]										
A	82	87	78	71	71	95	91	84	86	69
B	92	86	90	80	87	90	88	92	101	92
C	95	86	79	85	79	103	88	97	100	90
D	92	86	95	90	94	109	91	93	96	85
Commercial slag:										
No. 1	103	100	92	104	97	106	95	88	98	96
No. 2	103	95	95	98	103	88	97	101	107	97
No. 3	101	106	90	99	101	81	97	94	94	94
No. 4	90	99	112	99	91	108	100	93	96	95
No. 5	96	97	92	97	100	95	101	106	100	97
No. 6	92	101	99	98	104	77	97	87	95	101
No. 7	97	92	101	95	85	93	97	96	100	98
No. 8	94	106	100	105	107	100	110	106	92	114
No. 9	105	103	103	102	108	111	115	104	101	108
No. 10	90	100	92	94	102	95	109	100	93	94
No. 11	107	99	107	100	102	99	91	95	100	93
No. 12	98	107	109	103	109	95	87	85	100	103
No. 13	101	108	105	104	102	112	91	103	102	101
No. 14	98	109	104	114	109	99	93	96	99	93
No. 15	98	108	102	102	99	87	97	100	100	109
No. 16	95	106	114	108	104	98	99	92	101	98
Average	98	102	101	101	101	96	98	97	99	99
Commercial gravel and stone:										
No. 17	94	87	85	82	91	100	99	101	85	92
No. 18	104	96	101	99	101	106	95	100	99	97
No. 19	97	95	90	89	93	103	105	106	102	104
No. 20	109	95	96	98	91	108	108	125	113	108
No. 21	98	97	97	91	94	92	95	97	96	101
No. 22	90	86	89	87	84	85	83	86	85	87
No. 23	99	104	104	110	104	112	101	103	122	110
No. 24	108	103	104	104	103	96	93	93	95	91
No. 25	110	102	108	117	117	119	114	123	111	115
No. 26	114	93	97	90	97	116	99	108	106	97
No. 27	108	104	105	108	96	116	122	125	114	111
No. 28	97	103	105	103	104	102	105	102	99	96
Average	102	97	98	98	98	105	102	106	102	101

[a] Since these are non-commercial materials, the results are not used in the average.

Figure 3 shows the relative compressive strengths of concrete composed of commercial slag and commercial gravel and stone at various ages. It will be noted that concrete composed of commercial slag aggregates show slightly higher strengths at all ages, except 7 days, than concrete composed of stone and gravel aggregate. This difference in strength, however, is not great as is indicated by a study of the relative strengths given in Table X.

Very uniform concrete strengths are developed by all aggregates.

Figure 3 shows the relative flexural strengths of the concrete composed of commercial slag, stone and gravel as coarse aggregate at various ages. A study of this figure shows more or less erratic results, the commercial slag results at 2 and 3 months being abnormally low, while the gravel and stone results at 2 months and 2 yr. are abnormally high. The flexural strength developed by the commercial slag aggregate was slightly less at all ages than that developed by the gravel and stone aggregate.

TABLE XI.—RATIO OF COMPRESSIVE TO FLEXURAL STRENGTH OF CONCRETE, MOIST STORAGE.

Mix 6.3 sacks per cubic yard.

Aggregate	Ratio, Compressive to Flexural Strength				
	Age at Test, 7 days	Age at Test, 28 days	Age at Test, 3 months	Age at Test, 1 yr.	Age at Test, 5 yr.
Non-commercial slag:[a]					
A	5.6	6.2	7.0	6.2	7.5
B	6.5	6.7	7.4	6.0	6.9
C	5.9	6.7	6.1	6.3	6.5
D	5.4	6.4	7.7	7.0	8.1
Commercial slag:					
No. 1	6.3	7.2	7.9	8.0	7.3
No. 2	7.6	6.6	7.1	6.9	7.8
No. 3	8.1	7.5	7.2	7.9	7.9
No. 4	5.4	6.8	9.1	7.7	7.0
No. 5	6.5	6.5	6.5	7.3	7.5
No. 6	7.6	7.0	8.5	7.7	7.6
No. 7	6.7	6.5	7.9	7.1	6.4
No. 8	6.0	6.5	7.1	8.6	6.9
No. 9	6.1	6.1	7.5	7.6	7.4
No. 10	6.1	6.2	7.0	7.6	7.9
No. 11	7.0	7.4	8.5	7.5	8.0
No. 12	6.7	8.4	9.7	7.8	7.7
No. 13	5.7	8.1	7.7	7.7	7.4
No. 14	6.3	8.0	8.2	8.6	8.6
No. 15	7.2	7.6	7.7	7.7	6.6
No. 16	6.2	7.3	9.4	8.1	7.8
Average	6.5	7.0	7.9	7.7	7.5
Commercial gravel and stone:					
No. 17	6.1	6.0	6.4	7.2	7.3
No. 18	6.9	7.0	7.5	7.1	6.9
No. 19	6.3	6.9	7.6	7.5	7.6
No. 20	7.2	7.6	8.4	8.2	8.3
No. 21	6.8	7.0	7.8	7.7	7.0
No. 22	5.9	6.1	6.6	7.8	7.5
No. 23	5.7	6.9	7.7	6.7	6.9
No. 24	6.1	6.0	6.4	7.2	7.3
No. 25	6.3	6.4	6.7	6.3	7.4
No. 26	6.4	6.0	5.7	6.4	6.2
No. 27	6.0	6.1	6.4	6.5	6.5
No. 28	6.2	6.8	7.8	7.8	8.0
Average	6.3	6.6	7.1	7.2	7.2
Grand average	6.5	6.9	7.6	7.5	7.3

[a] Since these are non-commercial materials, the results are not used in the average.

Figure 4 shows the relative value, as indicated by compressive and flexural strengths of concrete, of all aggregates studied. The comparison is made on a relative value basis with the average results of all twenty-eight commercial aggregates considered as 100 per cent.

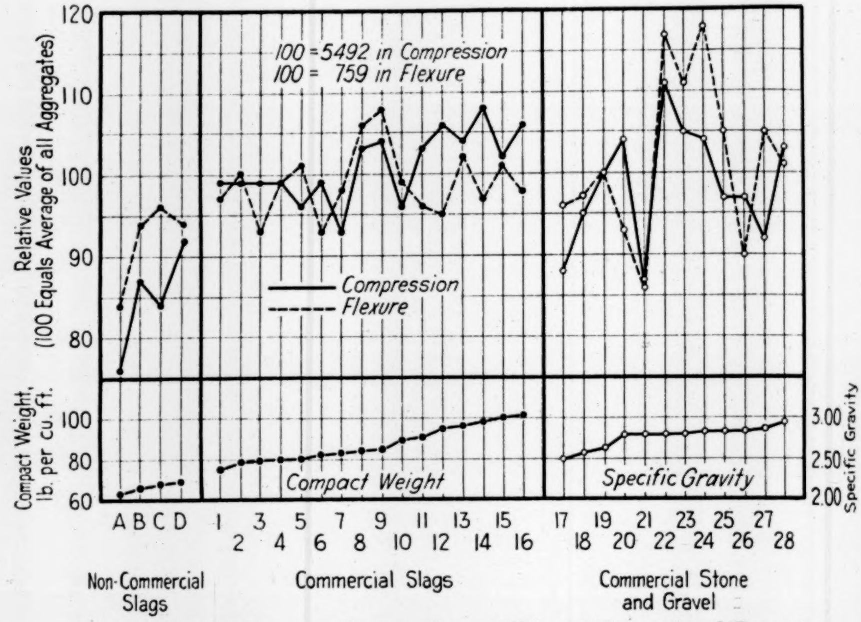

FIG. 4.—Relation Between Compressive and Flexural Strengths of Concrete.

32 aggregates, equal cement content (6.3 sacks per cu. yd.), moist storage. Data from Tables III and X.

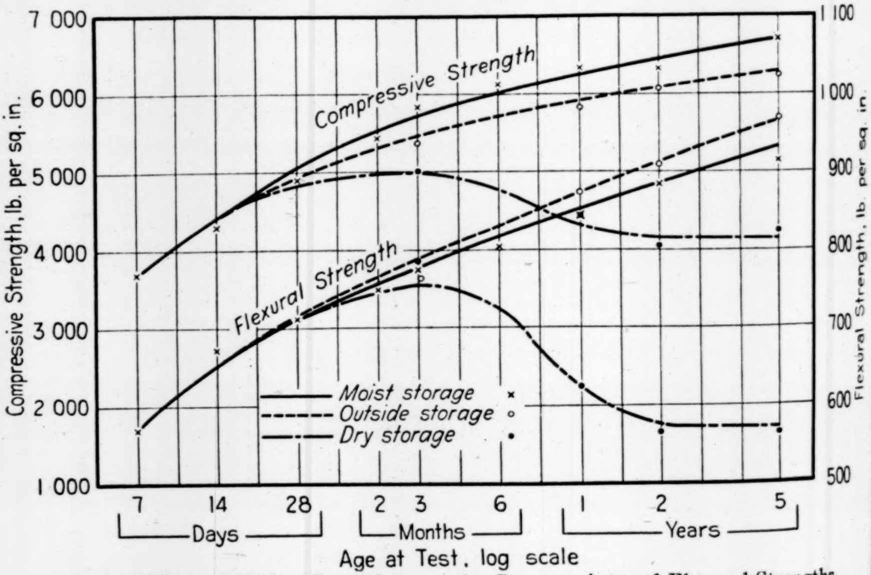

FIG. 5.—Effect of Curing Conditions on the Compressive and Flexural Strengths of Concrete.

10 aggregates, equal cement content (6.3 sacks per cu. yd.), moist, dry and outside storage. Data from Tables VIII, IX and XII.

Figure 5 shows the compressive strengths of moist-cured specimens at all ages and the corresponding strengths of dry and outside cured specimens at the ages of 3 months, and 1, 2 and 5 yr. It will be noted that there is a decided falling off in strength of the dry-stored specimens as compared with the moist-cured concrete. The strengths developed at 1, 2 and 5 yr. in dry storage are 89, 82 and 86 per cent, respectively, of the 28-day strengths and 69, 64 and 62 per cent, respectively, of the concrete strengths developed at the same ages in moist storage.

TABLE XII.—COMPRESSIVE AND FLEXURAL STRENGTHS OF CONCRETE.
Moist, dry and outside storage. Mix 6.3 sacks per cubic yard.

Commercial Aggregate	28 days	3 months			1 yr.			2 yr.			5 yr.		
	M.	M.	D.	O.	M.	D.	O.	M.	D.	O.	M.	D.	O.
COMPRESSIVE STRENGTH, LB. PER SQ. IN.[a]													
No. 2	4690	5540	5360	6020	6230	4710	6380	6480	4370	6540	6870	4330	6590
No. 7	4580	5850	5200	5120	6030	4730	5510	5780	4330	5750	5700	4600	5880
No. 8	5270	5830	5190	5960	6710	4800	6120	6900	4440	6550	7140	4560	5940
No. 11	4910	6230	5110	5530	6390	4290	5880	6250	4040	5980	6790	4180	6280
No. 12	5300	6340	4660	5420	6590	4060	6000	6200	3880	6080	7260	4010	6070
No. 14	5420	6060	4980	5300	7260	4300	6410	7140	4000	6500	7290	3920	6250
No. 17	4340	4960	4110	4300	5230	3800	4510	5040	3300	5140	6100	3970	5690
No. 18	4790	5660	4850	5220	5820	4110	6060	6000	3780	6050	6300	4090	6490
No. 22	5070	6250	5250	5800	7420	4270	5690	7550	3960	6060	7830	4280	7120
No. 25	4620	5630	5280	5170	5720	4390	5890	5980	4190	5970	6460	4390	6340
Average	4896	5835	5009	5384	6340	4346	5845	6332	4029	6062	6774	4233	6265
Per cent of 28-day moist strength	100	119	102	110	129	89	119	129	82	124	138	86	128
FLEXURAL STRENGTH, LB. PER SQ. IN.													
No. 2	705	780	760	865	910	640	950	865	560	930	885	555	1010
No. 7	705	740	790	605	850	655	790	855	535	945	895	565	1010
No. 8	805	820	820	815	785	595	940	915	565	955	1035	540	1050
No. 11	665	735	860	725	850	660	910	845	560	840	850	590	915
No. 12	635	655	640	805	850	500	950	820	495	995	940	555	940
No. 14	680	740	905	760	845	695	865	915	645	925	850	625	950
No. 17	720	780	785	700	725	605	705	855	550	775	835	520	945
No. 18	690	750	630	695	815	535	820	910	510	845	915	490	935
No. 22	830	945	940	825	940	715	960	990	680	1000	1045	685	1055
No. 25	720	830	705	690	905	615	840	905	565	865	880	550	910
Average	715	778	783	757	847	621	873	887	566	907	913	587	972
Per cent of 28-day moist strength	100	109	110	106	118	87	122	124	79	127	128	79	136

[a] M. = moist storage.
D. = dry storage.
O. = outside storage of test specimens.
Data from this table appear in Fig. 5.

The outside-stored specimens more nearly keep pace with the moist-stored concrete. There is a slightly lower strength, but the difference is not so pronounced as it is in the dry-stored material. This is undoubtedly due to the fact that the concrete stored outside on the ground takes up a considerable amount of moisture, which aids materially in the curing, although not being as thoroughly cured as the specimens from the moist room.

Figure 5 also shows the effect of dry and outside storage on the flexural strength of concrete beams at 3 months and 1, 2 and 5 yr. of age. The effect of the dry storage conditions on the concrete is very pronounced, the strengths developed at 1, 2 and 5 yr. in dry storage being only 87, 79 and 79 per cent, respectively, of the 28-day strengths and 73, 64 and 62 per cent, respectively, of the concrete strengths developed at the same ages in moist storage. The outside-stored specimens developed slightly higher flexural strengths than those developed under moist storage conditions.

Figure 6 shows the relation of the abrasion loss on all coarse aggregates to the compressive strength of the resulting concrete. This figure shows the results for the various coarse aggregates plotted according to the decreasing value of the average standard and modified abrasion losses. Slag A shows the highest abrasion, lowest weight and lowest compressive strength of any of the slags studied. Slags A, B, C and D were all selected because of their extremely low weight and as representing materials which would not pass the ordinary specifications for unit weight. These materials all showed comparatively low compressive strengths.

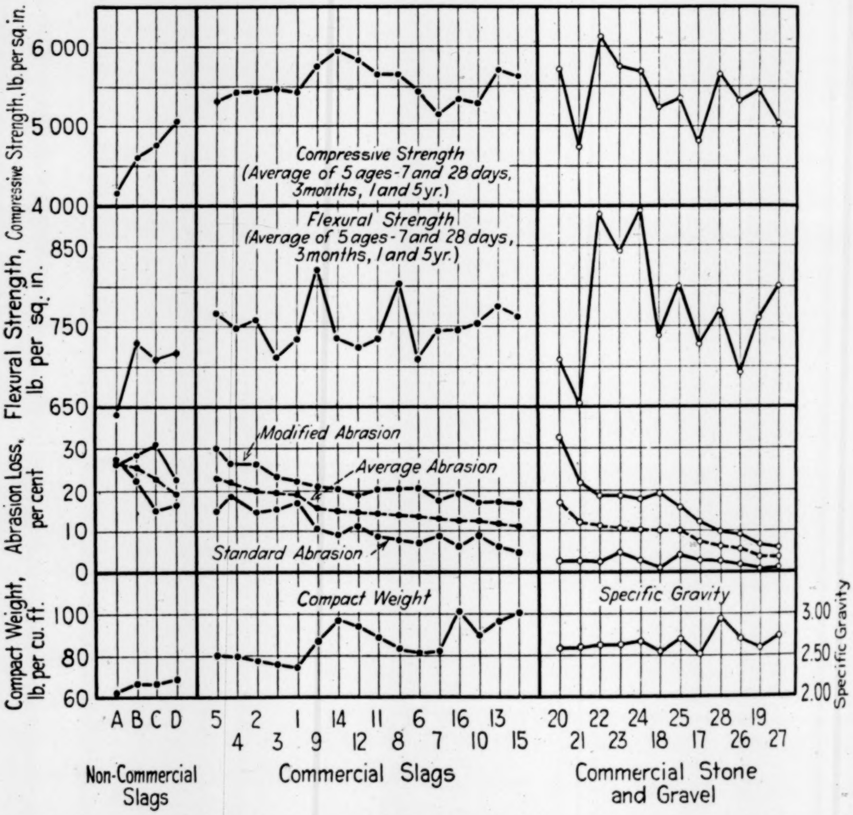

FIG. 6.—Relation of Abrasion Loss of Aggregate to Compressive and Flexural Strengths of Concrete.

Plotted according to average abrasion factor.
32 aggregates, equal cement content (6.3 sacks per cu. yd.), moist storage.
Data from Tables III, VIII and IX.

It will be noted that aggregate No. 20 shows a comparatively low standard abrasion loss but an exceedingly high modified abrasion loss. This material is very hard and shows excellent results in the standard abrasion test, which does not use an abrasive charge of steel balls. In the modified test, however, with an abrasive charge of steel balls this material seems to break up very badly and shows the highest modified abrasion of any of the aggregates studied. The compressive strength results, however, are very satisfactory. The abrasion loss of blast-furnace slag aggregate does not apparently affect in any way the compressive strength of the resulting concrete.

Figure 6 shows the relation of the abrasion of coarse aggregates to the flexural strengths of the resulting concrete. A study of this figure does not indicate any direct relation between abrasion and flexural strengths.

Figure 7 shows the relation of various characteristics of coarse aggregates to the resulting concretes. The materials have been plotted in the order of their increase in compact unit weight for slag aggregate and according to the increase in specific gravity for the stone and gravel aggregates. Increase in the unit weight of the aggregate should result in increased specific gravity and increase in the unit weight of the resulting concrete. This in general is true, the concrete weights increasing, of course, much less than the weight of the aggregate, due to the fact that the concrete contains a certain percentage of mortar weighing the same in all cases.

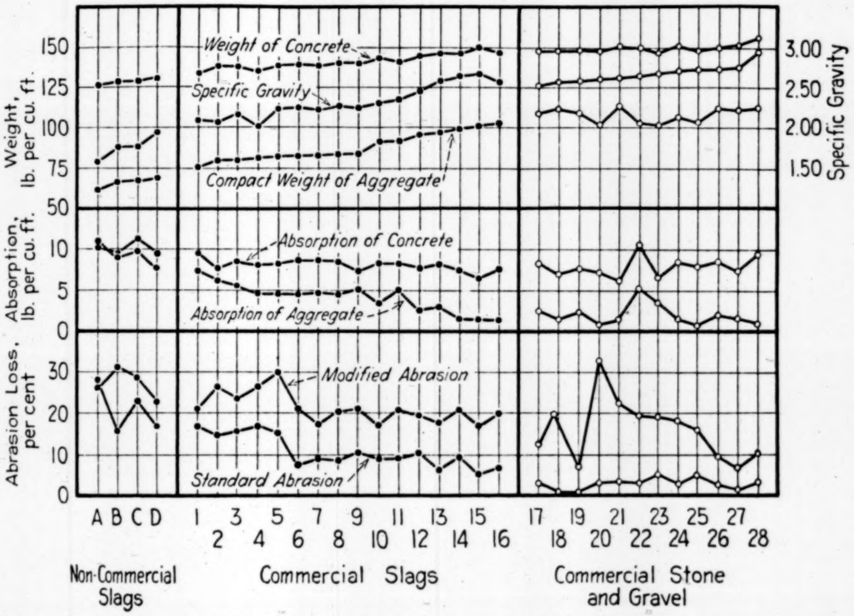

FIG. 7.—Comparisons of Various Physical Characteristics of Aggregates and Concretes.
32 aggregates, equal cement content (6.3 sacks per cu. yd.).
Data from Tables III, VII and XIII.

The absorption of the aggregates decreases as the weights increase, which is as would be expected. There is also a slight decrease in the absorption of the concrete as the weight of the coarse aggregate increases. This decrease in the absorption of the concrete is only slight, it being much less pronounced than the decrease of the absorption of the aggregate. Table XIII gives the average absorption of all commercial slag concretes as 8.1 lb. per cu. ft., and of all stone and gravel concretes as 7.9 lb. per cu. ft. This would indicate that the absorption to be expected in concrete composed of various types of coarse aggregates is practically the same. Both modified and standard abrasion losses, in general, decrease as the weight of the slag aggregate increases.

Figure 8 shows the relation between the unit weight and the chemical analysis of the slag aggregates, the materials being plotted in the order of increasing unit weight.

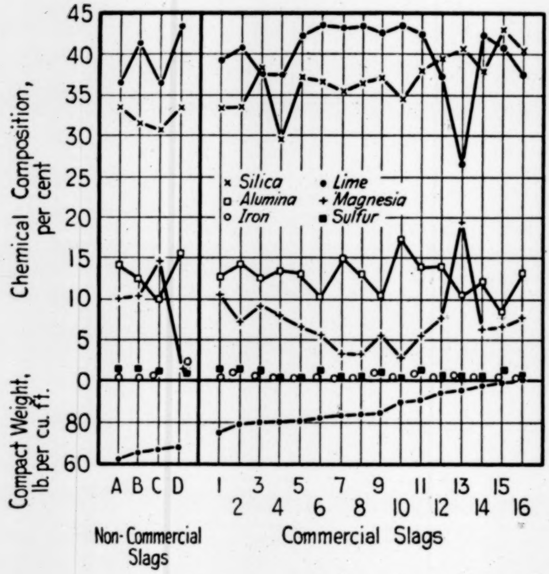

FIG. 8.—Relation Between Weight and Chemical Composition of 20 Slags.
Data from Tables II and III.

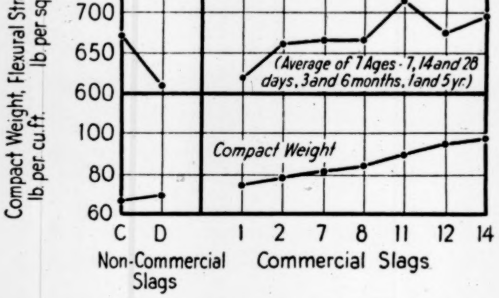

FIG. 9.—Relation of Compact Weight of Aggregate to Compressive and Flexural Strengths of Concrete.
Slag from 9 sources, equal cement content (5.4 sacks per cu. yd.), moist storage.
Data from Tables III and XVI.

Fairly uniform chemical compositions are noted for all slags, some exceptions being slag No. 13 and slag D. Slag No. 13 is a low-lime, high-magnesia slag and slag D is a high-lime, low-magnesia slag. A rather definite relationship between the silica content and the unit weight per cubic foot is observed from the fact that all slags having less than 34 per cent silica do not exceed 75 lb. in weight and, with one exception, slags having over 38 per cent silica have a unit weight of over 85 lb. With two exceptions, slags having silica contents ranging between 34 and 38 per cent have unit weights ranging from 75 to 85 lb. per cu. ft. The unit weight referred to in all instances is the compact weight of aggregate graded as used in concrete.

TABLE XIII.—WEAR AND ABSORPTION OF CONCRETE, MOIST STORAGE.
Mix 6.3 sacks per cubic yard.

Aggregate	Depth of Wear, in.			Absorption, per cent			Absorption, lb. per cu. ft.		
	28 days	3 months	Average	28 days	3 months	Average	28 days	3 months	Average
Non-commercial slag:[a]									
A	0.131	0.061	0.096	6.76	9.06	7.91	8.5	11.5	10.0
B	0.082	0.050	0.066	6.99	8.08	7.54	9.0	10.4	9.7
C	0.056	0.041	0.048	8.99	8.22	8.61	11.6	10.6	11.1
D	0.051	0.041	0.046	6.46	7.32	6.89	8.5	9.7	9.1
Commercial slag:									
No. 1	0.051	0.059	0.055	7.83	6.56	7.20	10.2	8.6	9.4
No. 2	0.130	0.055	0.093	5.46	5.85	5.65	7.6	8.1	7.8
No. 3	0.084	0.048	0.065	6.17	6.24	6.20	8.5	8.6	8.5
No. 4	0.061	0.062	0.062	5.62	6.27	5.94	7.6	8.4	8.0
No. 5	0.098	0.073	0.086	6.59	5.19	5.89	9.1	7.2	8.1
No. 6	0.093	0.053	0.073	6.41	6.56	6.48	8.8	9.0	8.9
No. 7	0.068	0.048	0.058	6.50	6.23	6.36	9.0	8.6	8.8
No. 8	0.096	0.049	0.073	6.09	6.28	6.18	8.6	8.8	8.7
No. 9	0.077	0.040	0.058	4.81	5.72	5.26	6.7	8.0	7.3
No. 10	0.100	0.071	0.086	5.87	4.48	5.67	8.5	7.8	8.1
No. 11	0.064	0.056	0.060	5.71	5.97	5.84	8.1	8.4	8.3
No. 12	0.103	0.066	0.085	5.69	4.99	5.34	8.3	7.3	8.2
No. 13	0.096	0.067	0.082	6.17	5.01	5.59	9.1	7.3	8.2
No. 14	0.070	0.047	0.059	5.70	4.56	5.13	8.3	6.6	7.5
No. 15	0.117	0.044	0.081	4.32	4.49	4.41	6.4	6.7	6.6
No. 16	0.097	0.067	0.082	5.11	5.00	5.05	7.5	7.3	7.4
Average	0.088	0.056	0.072	5.88	5.59	5.76	8.3	7.9	8.1
Commercial gravel and stone:									
No. 17	0.061	0.034	0.048	5.40	5.78	5.59	7.9	8.5	8.2
No. 18	0.071	0.049	0.060	4.75	4.70	4.73	7.0	6.9	7.0
No. 19	0.054	0.050	0.052	5.13	5.45	5.29	7.6	8.0	7.8
No. 20	0.068	0.054	0.061	4.77	5.02	4.90	7.0	7.4	7.2
No. 21	0.068	0.051	0.060	4.14	3.89	4.02	6.2	5.8	6.0
No. 22	0.068	0.056	0.062	6.96	7.23	7.10	10.3	10.8	10.5
No. 23	0.055	0.061	0.058	4.67	4.59	4.63	6.8	6.7	6.7
No. 24	0.047	0.053	0.050	6.59	4.74	5.67	9.9	7.1	8.5
No. 25	0.060	0.060	0.060	6.06	4.65	5.36	8.9	6.9	7.9
No. 26	0.066	0.062	0.064	5.16	6.14	5.65	7.7	9.2	8.4
No. 27	0.063	0.035	0.049	4.46	5.05	4.75	6.7	7.6	7.2
No. 28	0.066	0.048	0.057	5.61	6.41	6.01	8.7	10.0	9.3
Average	0.062	0.051	0.057	5.31	5.31	5.31	7.9	7.9	7.9

[a] A, B, C and D non-commercial material. Results not used in average.
Data for this table appear in Fig. 7.

1:2.4:3.6 Mix Slag Concrete (5.4 sacks per cu. yd.):

Results of tests on concrete of nine different slags as coarse aggregate, tested in the proportion of 1:2.4:3.6 by dry rodded volume (5.4 sacks of cement per cubic yard of finished concrete), are shown in Tables XIV, XV, XVI, XVII, XVIII and XX, also in Figs. 9 to 11.

Table XIV shows the results of yield tests on the 1:2.4:3.6 mix together with the average slump and flow and the net water-cement ratio. Table XV shows the proportions of the concrete materials by absolute volume. Table XVI shows the results of the compressive and flexural strengths of the concretes at all ages. Table XVII shows the relative compressive and flexural strengths developed by each aggregate as compared with the average strengths of all nine slags used, and Table XVIII shows the ratio of compressive to flexural strength.

TABLE XIV.—YIELD TESTS OF CONCRETE.

Mix 5.4 sacks per cubic yard. Mixed by dry rodded volume, slag concrete 1:2.4:3.6.

Aggregate	Slump, in.	Flow	Net Water-Cement Ratio, $\frac{w}{c}$	Quantities of Concrete per cubic yard						Mortar-Void Ratio[c]	Weight per cu. ft. of Concrete, lb.	Absorption	
				Cement Sacks		Sand		Coarse Aggregate				per cent	lb. per cu. ft.
				Actual	Computed[b]	cu. ft.	lb.	cu. ft.	lb.				
Non-commercial slag:[a]													
C	$2\frac{1}{2}$	179	0.93	5.4	5.2	12.9	1393	19.3	1299	2.21	128.0	9.6	12.3
D	$2\frac{1}{2}$	179	0.93	5.6	5.3	13.5	1432	20.2	1409	1.96	132.1	9.3	12.3
Commercial slag:													
No. 1	3	185	0.93	5.4	5.3	13.0	1411	19.5	1466	1.97	132.9	8.5	11.3
No. 2	$2\frac{1}{4}$	179	0.93	5.5	5.2	13.1	1416	19.7	1557	2.17	136.0	7.4	10.1
No. 7	$2\frac{1}{2}$	181	0.93	5.3	5.2	12.8	1385	19.2	1594	2.09	136.5	6.8	9.3
No. 8	$2\frac{1}{2}$	183	0.93	5.4	5.2	13.0	1403	19.5	1642	2.06	140.0	7.2	10.1
No. 11	2	176	0.93	5.3	5.2	12.7	1366	19.0	1717	2.20	140.7	6.9	9.7
No. 12	$2\frac{1}{4}$	183	0.93	5.3	5.1	12.7	1366	19.0	1814	2.28	143.0	6.1	8.7
No. 14	$2\frac{1}{4}$	176	0.93	5.3	5.2	12.8	1380	19.2	1882	2.10	144.7	6.0	8.7
Average	2.4	180	0.93	5.4	5.2	12.9	1389	19.3	1667	2.12	139.1	7.0	9.7

[a] Since these are non-commercial materials, the results are not used in average.

[b] Computed from the absolute volume of the materials.

[c] Obtained by dividing the sum of the absolute volumes of cement plus sands plus water by the volume of voids in the compact coarse aggregate.

TABLE XV.—PROPORTIONS OF AGGREGATE FOR CONCRETE BY ABSOLUTE VOLUME IN CUBIC FEET PER SACK OF CEMENT.

Computed from unit weight and specfic gravity of materials used.

Aggregate	Cement	Sand	Slag	Water	Total	Cement per cu. yd., sacks
Non-commercial slag:						
C	0.490	1.569	2.233	0.930	5.222	5.17
D	0.490	1.569	2.074	0.930	5.063	5.33
Commercial slag:						
No. 1	0.490	1.569	2.082	0.930	5.071	5.35
No. 2	0.490	1.569	2.220	0.930	5.209	5.18
No. 7	0.490	1.569	2.166	0.930	5.155	5.24
No. 8	0.490	1.569	2.151	0.930	5.140	5.25
No. 11	0.490	1.569	2.243	0.930	5.232	5.16
No. 12	0.490	1.569	2.281	0.930	5.270	5.12
No. 14	0.490	1.569	2.168	0.930	5.157	5.24
Average	0.490	1.569	2.187	0.930	5.176	5.22

TABLE XVI.—COMPRESSIVE AND FLEXURAL STRENGTHS OF CONCRETE.

Mix, 5.4 sacks per cubic yard.

Aggregate	7 days	14 days	28 days	2 months	3 months	6 months	1 yr.	2 yr.	5 yr.
COMPRESSIVE STRENGTH, LB. PER SQ. IN.									
Non-commercial slag:[a]									
C	2560	3120	3460	....	4080	4340	4570	....	4570
D	2420	2980	3410	....	3640	3850	4080	....	4750
Commercial slag:									
No. 1	2480	3190	4050	....	4020	4730	5120	....	5180
No. 2	2480	3080	3660	4400	4370	4600	4750	5190	5570
No. 7	2360	2740	3420	4050	4260	4350	4360	4500	5180
No. 8	2170	2980	3700	4080	4290	4780	4790	4950	5480
No. 11	2550	3140	3730	4350	4640	4770	4670	4850	5480
No. 12	2510	3180	3730	4390	4550	4620	4440	4620	4900
No. 14	2640	3000	3710	4110	4320	5000	5050	4980	5520
Average	2460	3040	3710	4230	4350	4690	4740	4850	5330
FLEXURAL STRENGTH, LB. PER SQ. IN.									
Non-commercial slag:									
C	510	560	640	...	750	730	765	...	740
D	465	575	620	...	670	645	650	...	640
Commercial slag:									
No. 1	425	555	565	...	585	700	755	...	740
No. 2	555	585	635	590	670	705	715	690	760
No. 7	555	580	635	635	675	790	750	820	765
No. 8	605	615	690	840	725	635	645	740	750
No. 11	515	645	665	730	715	815	800	845	850
No. 12	480	590	675	710	715	670	770	795	840
No. 14	590	545	615	645	725	785	815	840	800
Average	530	590	640	690	685	715	750	790	785

[a] Since these are non-commercial materials, the results are not used in average.

Data from this table appear in Figs. 9, 10 and 11.

TABLE XVII.—RELATIVE VALUES OF COMPRESSIVE AND FLEXURAL STRENGTHS OF CONCRETE, MOIST STORAGE.

Mix 5.4 sacks per cubic yard.

Aggregate	7 days	14 days	28 days	3 months	6 months	1 yr.	2 yr.	5 yr.
RELATIVE VALUES IN COMPRESSION								
Average, lb. per sq. in.	2460	3040	3710	4350	4690	4740	4850	5330
Non-commercial slag:								
C	104	103	93	94	93	97	...	86
D	98	98	92	84	82	86	...	89
Commercial slag:								
No. 1	101	105	109	92	101	108	...	97
No. 2	101	101	99	101	98	100	107	104
No. 7	96	90	92	98	93	92	93	97
No. 8	88	98	100	99	102	101	102	103
No. 11	103	103	101	107	102	99	100	103
No. 12	102	105	101	105	98	94	95	92
No. 14	108	99	100	99	107	107	103	104
RELATIVE VALUES IN FLEXURE								
Average, b. per sq. in	530	590	640	685	715	750	790	785
Non-commercial slag:								
C	96	95	100	109	102	102	...	94
D	88	97	97	98	90	87	...	82
Commercial slag:								
No. 1	80	94	88	85	98	101	...	94
No. 2	105	99	99	98	99	95	87	97
No. 7	105	98	99	99	97	100	104	97
No. 8	114	104	108	106	89	86	94	96
No. 11	97	109	104	104	114	107	107	108
No. 12	91	100	105	104	94	103	101	107
No. 14	111	92	96	106	110	109	106	102

Table XIX shows the results of exposure tests on the concrete composed of each of the coarse aggregates. After 5 yr. exposure the 1:2:3 mix concrete was only moderately affected as compared to the 1:2.4:3.6 concrete. Specimens of the 1:2.4:3.6 concrete were not exposed on the sewage-disposal beds until 1931. At the time of the examination in January, 1935, they had therefore had only 3 yr., 4 months' exposure. At that time, however, all of the specimens showed decided scaling and disintegration due to the weathering action.

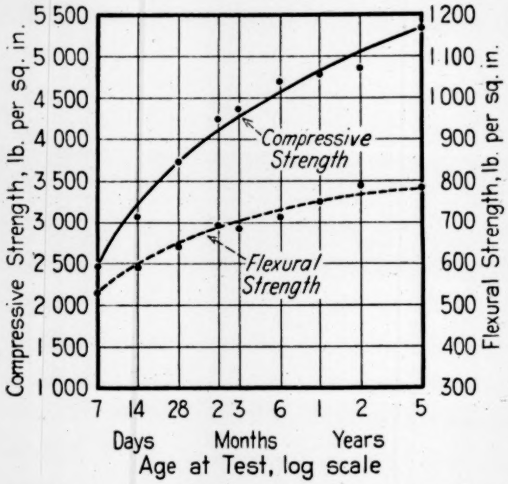

FIG. 10.—Relative Change in Compressive and Flexural Strengths of Concrete with Age.
Commercial slag aggregate from 7 sources, equal cement content (5.4 sacks per cu. yd.), moist storage. Data from Table XVI.

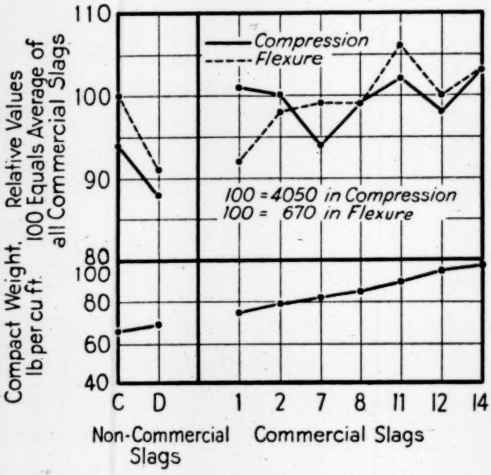

FIG. 11.—Relation Between Compressive and Flexural Strengths of Concrete Slag Aggregate from 9 Sources.
Equal cement content (5.4 sacks per cu. yd.), moist storage. Data from Tables III and XVI.

A comparison of the results on the two mixes shows that it is of utmost importance to give careful consideration to the cement content of concrete used in structures subject to severe weathering conditions. The 1:2.4:3.6 mix concrete would have sufficient strength for use in most structures. However, it would not be sufficiently resistant to weathering for use in such work as walls of the beds for sewage trickling filters. (No stone or gravel concrete was tested in this mix.)

Figure 9 shows the relation between the compact unit weight of slag aggregate from nine sources and the compressive and flexural strength of the resulting concrete under moist storage conditions. Slags C and D were non-commercial, light-weight material. Concrete containing all nine aggregates was tested at the following ages: 7, 14 and 28 days, 3 and 6 months, and 1 and 5 yr. The results as shown in the figure represent the average of the strengths developed by the concrete at all ages, each point representing the average of 21 cylinders or 21 beam breaks tested at seven different intervals. The flexural strengths increase slightly with increase in the unit weight of the aggregate. The compressive strength of the concrete from the commercial slags is not affected by the unit weight of the aggregate.

Figure 10 shows the average increase in both compressive and flexural strengths with age. Figure 11 shows the relative value, as indicated by the compressive and flexural strengths of concrete of all aggregates studied with the 5.4 sack mix. The comparison is made on a relative value basis with the average results of all seven commercial aggregates considered as 100 per cent.

TABLE XVIII.—RATIO OF COMPRESSIVE TO FLEXURAL STRENGTHS OF CONCRETE, MOIST STORAGE.

Mix 5.4 sacks per cubic yard.

Aggregate	Ratios, Compressive to Flexural Strength								
	Age at Test, 7 days	Age at Test, 14 days	Age at Test, 28 days	Age at Test, 2 months	Age at Test, 3 months	Age at Test, 6 months	Age at Test, 1 yr.	Age at Test, 2 yr.	Age at Test, 5 yr.
Non-commercial slag:[a]									
C	5.0	5.6	5.4	...	5.4	6.0	6.0	...	6.2
D	5.2	5.2	5.5	...	5.4	6.0	6.3	...	7.4
Commercial slag:									
No. 1	5.8	5.8	7.9	...	6.9	6.8	6.8	...	7.0
No. 2	4.5	5.3	5.8	7.4	6.5	6.5	6.7	7.5	7.3
No. 7	4.3	4.7	5.4	6.4	6.3	6.3	5.8	5.5	6.8
No. 8	3.6	4.8	5.3	4.9	5.9	7.5	7.5	6.7	7.3
No. 11	4.9	4.9	5.6	6.0	6.5	5.9	5.8	5.7	6.5
No. 12	5.2	5.4	5.5	6.2	6.4	6.9	5.8	5.8	5.8
No. 14	4.5	5.5	6.0	6.4	6.0	6.4	6.2	5.9	6.9
Average	4.6	5.1	5.8	6.1	6.3	6.6	6.3	6.1	6.8

[a] Since these are non-commercial materials, the results are not used in the average.

The data given are very enlightening as to the characteristics of blast-furnace slag which are pertinent in determining its value as a concrete aggregate and also show other facts concerning the quality of concrete which should be of value to concrete engineers. The usual specification requirements for blast-furnace slag are discussed briefly, as well as other outstanding facts which have been developed:

Weight per Cubic Foot.—Most specifications carry a limiting minimum weight of 70 lb. per cu. ft. of compact material for grade A slag. Experience in handling slag concrete shows that the extremely light slags are somewhat difficult to place, this being especially true in concrete road construction where the extremely light particles are apt to float to the top of the concrete, catch on the finishing belt and otherwise give trouble in securing a satisfactory finish on the surface. These extremely light particles, covered as they are by a very thin film of mortar, tend to produce pits in the road surface after a number of years of service by the breaking away of the thin mortar film over the particle of light material.

Experience has further shown that slag weighing 70 lb. per cu. ft. or more can be satisfactorily handled without trouble from finishing or subsequent pitting. The strength results shown in this investigation also indicate that entirely satisfactory concrete from this point of view is produced by the use of material weighing 70 lb. per cu. ft. or over. Aggregates weighing less than 70 lb. per cu. ft. did not give strengths as good as the others, which leads to the obvious conclusion that the specification of a limiting unit weight on blast-furnace slag is a definite means of determining quality and, further, that a minimum limit of 70 lb. per cu. ft. of compact material is a satisfactory limit to place in specifications for slag aggregate.

TABLE XIX.—SOUNDNESS OF CONCRETE AS INDICATED BY EXPOSURE TESTS.

Concrete exposed on Canton, Ohio, sewage-disposal bed.

Aggregate	Condition of Concrete	Condition of Concrete	Loss in Weight, per cent	Condition of Concrete	Loss in Weight, per cent
CONCRETE PLACED ON BEDS MARCH 5, 1930, MIX 6.3 SACKS PER CUBIC YARD					
	After 1 yr., 6 months' Exposure	After 2 yr., 3 months' Exposure		After 4 yr., 10 months' Exposure	
Non-commercial slag:					
A	Good	Good	0	Scaled and chipped	1.7
B	Good	Good	0	Checked and chipped, corners	0.8
C	Good	Good	0	Good	0
D	Good	Chipped on corners	1.9	Chipped on corners	3.4
Commercial slag:					
No. 1	Good	Good	0	Good	0
No. 2	Good	Good	0	Scaled and checked, top	0.9
No. 3	Good	Good	0	Scaled and chipped, top	12.
No. 4	Good	Slightly checked	0	Scaled on top	2.5
No. 5	Good	Good	0	Slightly scaled, top	0
No. 6	Good	Good	0	Scaled on top	0.7
No. 7	Good	Good	0	Slightly scaled and checked	0
No. 8	Good	Slightly checked	0	Slightly checked	0.5
No. 9	Good	Good	0	Good	0
No. 10	Good	Good	0	Slightly chipped, corners	0
No. 11	Good	Slightly checked	0	Slightly checked	0
No. 12	Good	Slightly checked	0	Slightly checked	0
No. 13	Good	Good	0	Good	0
No. 14	Good	Good	0	Scaled and chipped	1.1
No. 15	Good	Good	0	Scaled and checked on top	0.9
No. 16	Good	Good	0	Slightly scaled on top	0
Commercial gravel and stone:					
No. 17	Good	Good	0	Good	0
No. 18	Good	Good	0	Slightly scaled, top	0
No. 19	Good	Good	0	Good	0
No. 20	Good	Good	0	Good	0
No. 21	Good	Good	0	Good	0
No. 22	Good	Good	0	Good	0
No. 23	Good	Good	0	Good	0
No. 24	Good	Good	0	Good	0
No. 25	Good	Good	0	Good	0
No. 26	Good	Good	0	Good	0
No. 27	Good	Good	0	Checked, chipped, corners	1.3
No. 28	Good	Slightly checked	0	Slightly checked	0
CONCRETE PLACED ON BEDS SEPTEMBER 28, 1931, MIX 5.4 SACKS PER CUBIC YARD					
	After 9 months' Exposure			After 3 yr., 4 months' Exposure	
Non-commercial slag:					
C	Good		0	Badly disintegrated	5.6
D	Good		0	Badly disintegrated	4.2
Commercial slag:					
No. 1	Good		0	Slightly disintegrated	2.3
No. 2	Scaling and disintegrating		1.1	Badly disintegrated	11.2
No. 7	Scaling and disintegrating		1.7	Badly disintegrated	8.0
No. 8	Scaling and disintegrating		2.6	Badly disintegrated	21.6
No. 11	Scaling and disintegrating		1.3	Badly disintegrated	11.4
No. 12	Scaling and disintegrating		0.9	Badly disintegrated	9.1
No. 14	Scaling and disintegrating		2.6	Badly disintegrated	19.0

Deval Abrasion (*Standard and Modified*).—Experience with the Deval abrasion test on blast-furnace slag has shown very definitely that as a test, abrasion is very unsatisfactory because of the erratic results obtained on the same material, not only between different laboratories but also as obtained in a single laboratory. Other investigations have definitely proven that the abrasion test is one the results of which cannot be duplicated with any degree of accuracy by different operators working on the same material.[1] This fact alone makes the abrasion test very undesirable when applied to slag.

The results of this investigation indicate that specifications containing an abrasion limitation would be no better than those containing a minimum weight requirement only. While it is true that slags A, B, and C, representing the three lightest materials studied, show the greatest abrasion loss, yet slag D, weighing 69.7 lb. per cu. ft. shows fairly good abrasion results, but this material does not show nearly so good strength as four other materials with higher abrasion losses. It may therefore be concluded that no Deval abrasion requirement should be written into specifications for blast-furnace slag.

Sulfur.—This investigation does not deal directly with the question of the sulfur content of slag other than determining the amount of sulfur in the various materials. A sulfur limitation is very rare in slag specifications, although occasionally such a limitation is found. This limitation has been used because of the fear that sulfur in slag used as concrete aggregate would have a tendency to attack reinforcement steel. On the contrary, slag contains only a very small percentage of sulfur, about the same as is found in portland cement, and the sulfur is in such form that it does not attack reinforcing steel. Slag, as a matter of fact, has a tendency to protect steel when in direct contact with it. Experience in the examination of slag concrete that has had many years of service has definitely proven that there is nothing in blast-furnace slag which will attack steel reinforcement.[2] The writing of a sulfur limitation in slag specifications, therefore, is entirely meaningless and does not in any way enhance the value of the specification or the resulting material.

Age.—A few specifications for blast-furnace slag require that the material shall not be used until it has been in the pits or storage piles for a period of several months. Table I shows that the slags used in this investigation varied in age from 3 days to 3 yr., most of the material being comparatively new when crushed. Again, experience has shown that the aging of slag for long periods does not enhance its value as a concrete aggregate. Ordinarily the molten slag from the blast furnaces reaches the commercial deposits in one of three ways: First, it may be allowed to run from the furnaces in a molten stream direct to small commercial pits located immediately adjacent to the furnace; second, the molten slag may be transported in ladles mounted on standard railroad equipment and deposited in rather large, regularly defined pits located at a considerable distance from the furnace; third, the molten slag may be transported in ladles and deposited in a commercial bank where the slag flows unconfined over a considerable area. The age of the slag when crushed depends almost entirely on which one of the above methods is used in its processing.[3] Most of the commercial slag produced in the United States is the so-called "fresh" slag, that is, it is still hot and dry when excavated by the power shovels and sent to the crushing plant for processing.

Material in this condition screens readily, and a good, clean product is the result. There is nothing in this investigation or in the experience of the users of blast-furnace

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[1] F. H. Jackson, "Abrasion of Aggregates," *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 536 (1930).

[2] Blast-Furnace Slag as Concrete Aggregate, Report of Committee 201, Aggregate Specifications, *Proceedings*, Am. Concrete Inst., Vol. 27, pp. 198-200 (1930).

Report of Committee C-9 on Concrete and Concrete Aggregates, *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part I, p. 220 (1923).

[3] Blast-Furnace Slag as Concrete Aggregate, Report of Committee 201, Aggregate Specifications, *Proceedings*, Am. Concrete Inst., Vol. 27, p. 183 (1930).

TABLE XX.—SUMMARY OF TEST RESULT AVERAGES ON COMMERCIAL AGGREGATES.

DATA ON AGGREGATES	SLAG (16 Sources)	GRAVEL AND STONE (12 Sources)
SiO_2	37.69	......
Al_2O_3	12.79	......
FeO	0.73	......
MnO	0.41	......
CaO	40.16	......
MgO	7.28	......
S	1.00	......
Weight, lb. per cu. ft. (loose)	76.7	96.0
Weight, lb. per cu. ft. (compact)	87.5	107.7
Standard abrasion, per cent	10.6	2.7
Modified abrasion, per cent	21.2	15.8
Apparent specific gravity	2.30	2.65
Absorption, per cent by weight	2.9	1.1
Absorption, lb. per cu. ft., solid	4.0	1.9
Absorption, per cent, 30 min	1.6	0.6
Voids, per cent (loose)	46.7	41.8
Voids, per cent (compact)	39.0	34.8

DATA ON CONCRETES (6.3 SACK MIX)	SLAG	GRAVEL	STONE
Mix, dry rodded volume	1:2.00:3.00	1:1.67:3.09	1:1.96:2.94
Cement per cubic yard, sacks	6.3	6.2	6.3
Water-cement ratio (net)	0.75	0.70	0.75
Water, gallons per sack (net)	5.6	5.3	5.6

	SLAG (16 Sources)	GRAVEL AND STONE (12 Sources)
Mortar-void ratio	2.18	2.28
Slump, in	2.25	2.15
Flow	174.	174.
Weight per cubic foot, lb	141.6	149.5
Absorption tests (6.3 sack mix), lb. of water per cu. ft. concrete:		
At 28 days	8.3	7.9
At 3 months	7.9	7.9

			RELATIVE VALUES	
COMPRESSION (6.3 SACK MIX)	SLAG	GRAVEL AND STONE	SLAG	GRAVEL AND STONE
Moist storage:				
7 days	3590 (16)	3750 (12)	98	102
14 days	4320 (7)	4210 (6)	102	97
28 days	5070 (16)	4810 (12)	102	97
2 months	5610 (6)	5290 (6)	103	97
3 months	5880 (16)	5710 (12)	101	98
6 months	6330 (7)	5860 (6)	104	96
1 yr	6460 (16)	6250 (12)	101	98
2 yr	6460 (6)	6340 (6)	101	99
5 yr	6770 (16)	6540 (12)	101	98
Dry storage:				
3 months	5090 (6)	4880 (4)	102	97
1 yr	4480 (6)	4140 (4)	103	95
2 yr	4170 (6)	3800 (4)	104	94
5 yr	4270 (6)	4190 (4)	101	99
Outdoor storage:				
3 months	5560 (6)	5120 (4)	103	97
1 yr	6050 (6)	5540 (4)	103	95
2 yr	6230 (6)	5810 (4)	103	96
5 yr	6170 (6)	6410 (4)	98	102
FLEXURE (6.3 SACK MIX)				
Moist storage:				
7 days	550 (16)	595 (12)	96	105
14 days	680 (7)	690 (6)	99	101
28 days	720 (16)	740 (12)	98	102
2 months	730 (6)	810 (6)	94	106
3 months	745 (16)	815 (12)	97	106
6 months	805 (7)	840 (6)	98	102
1 yr	840 (16)	870 (12)	99	102
2 yr	870 (6)	935 (6)	97	104
5 yr	905 (16)	915 (12)	99	101
Dry storage:				
3 months	795 (6)	765 (4)	102	98
1 yr	625 (6)	615 (4)	101	99
2 yr	560 (6)	580 (4)	99	101
5 yr	570 (6)	560 (4)	101	95
Outdoor storage:				
3 months	775 (6)	730 (4)	103	96
1 yr	900 (6)	830 (4)	103	95
2 yr	930 (6)	875 (4)	103	96
5 yr	980 (6)	960 (4)	101	99

TABLE XX.—(*Continued*)

RATIO OF COMPRESSIVE TO FLEXURAL STRENGTH (6.3 SACK MIX)	SLAG	GRAVEL AND STONE
At 7 days	6.5	6.3
At 28 days	7.0	6.6
At 3 months	7.9	7.1
At 1 yr.	7.7	7.2
At 5 yr.	7.5	7.2

CONCRETE DATA (5.4 SACK MIX)	SLAG
Mix, dry rodded volume	1:2.4:3.6
Cement per cu. yd., sacks	5.4
Mortar-void ratio	2.12
W/C Ratio (net)	0.93
Water, gallons per sack (net)	7.0
Slump, in.	2.4
Flow	180.0
Weight per cu. ft., lb.	139.1

ABSORPTION (5.4 SACK MIX), lb. of water per cu. ft. concrete............... 9.7

5.4 SACK MIX	COMPRESSION	FLEXURE
At 7 days	2460 (7)	530 (7)
At 14 days	3040 (7)	590 (7)
At 28 days	3710 (7)	640 (7)
At 2 months	4230 (6)	690 (6)
At 3 months	4350 (7)	685 (7)
At 6 months	4690 (7)	715 (7)
At 1 yr.	4740 (7)	750 (7)
At 2 yr.	4850 (6)	790 (6)
At 5 yr.	5330 (7)	785 (7)

slag as concrete aggregate that would indicate any superiority of aged slag over fresh slag. There is, therefore, no point in placing a minimum age requirement in specifications for slag.

Soundness.—Blast-furnace slag is a remarkably sound aggregate as indicated by the sodium sulfate test, natural freezing and thawing, and service history after many years' exposure. Soundness of a concrete aggregate is an essential requirement in order to secure a resulting sound concrete. This desirable quality cannot be over-emphasized as there are too many examples of disintegrating concrete which could have been prevented had the proper materials, cement content, and construction methods been used. For this reason a soundness limitation in specifications for a concrete aggregate is a very desirable feature, the degree of soundness required depending somewhat upon the exposure and conditions which will surround a structure in which the material is used.

Table IV indicates that twenty cycles of the sodium sulfate test for soundness has practically no effect upon blast-furnace slag. Thousands of tests on slag show the material to be sound to a remarkable degree.[1] Reference to Table V indicates that the two years' exposure on the surface of a sewage-disposal bed in a northern Ohio climate has little effect upon any of the aggregates used in this series of tests. At the approximate 5-yr. period, slags A and C and aggregate No. 23 showed decided disintegration. Both slags were very light-weight materials, neither meeting the A.S.T.M. weight requirement of 70 lb. per cu. ft.

Effect of Curing Conditions.—(See Fig. 5.) The data presented show very clearly the necessity for moisture if the potential strength of concrete is to be developed. Also that in the absence of moisture the concrete not only fails to gain in strength but actually decreases in strength to a very marked degree. This fact should be of special interest to those designing buildings and other similar structures the concrete of which practically never receives any moisture except that taken from the air.

Effect of Cement Content on the Durability of Concrete.—The necessity for properly designed concrete mixes containing the proper amount of cement when used in exposed structures cannot be over-emphasized. There are many instances where the durability of the concrete is the deciding factor in the design of the mix and the resulting cement factor may be much greater than is necessary from the standpoint of the strength requirements. This fact is clearly demonstrated by the results of the exposure tests given in the report.

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[1] *Proceedings*, Am. Concrete Inst., Vol. 26 (1930).

CONCLUSIONS

There seem to be two important facts which stand out very prominently as the results of this investigation. The first of these is the effect of curing on the strengths of concrete after the lapse of long periods of time. This is brought out very clearly in Fig. 5 and is a point which should undoubtedly have more consideration than it is ordinarily given.

The second is the effect of the cement content of concrete on its durability, referred to above. In many instances durability of the resulting concrete, and not the strength, is, or should be, the determining factor in the design of a concrete mix.

A study of the data presented, together with a knowledge of the behavior of slag in service, leads to the conclusion that blast-furnace slag is a dependable and satisfactory aggregate for concrete. Its use results in concrete not particularly better nor worse than that developed by other aggregates. Hedging the material about with complicated specification limitations is meaningless, unnecessary and undesirable. The unit weight of the material is a measure of quality and a means by which only desirable slags may be accepted.

On the other hand, extremely heavy slags are no better than medium weight slags and for some purposes less desirable than the lighter materials. A compact weight of 70 lb. per cu. ft. graded as ordinarily required for concrete aggregate will insure satisfactory materials. Specifications for blast-furnace slag as aggregate for concrete should include the following:

1. *General Characteristics.*—The general characteristics as given in the A.S.T.M. Tentative Specifications for Concrete Aggregates (C 33 – 31 T),[1] are satisfactory.

2. *Deleterious Substances.*—Such deleterious substances as shale, coal and clay lumps are not applicable to slag. Other deleterious substances mentioned in the A.S.T.M. specifications, such as material removed by decantation and soft fragments, are applicable to slag and could logically be included in a slag specification.

3. *Grading.*—This is an important factor and should be included in all slag specifications.

4. *Weight per Cubic Foot.*—A weight per cubic foot requirement is the best method of assuring the use of slag having satisfactory qualities as a concrete aggregate and should be included in all slag specifications. The A.S.T.M. weight requirements for slag are satisfactory.

5. *Soundness.*—The use of a sound aggregate is of great importance, especially in concrete subject to severe exposure, and soundness requirements should be included in slag specifications.

The following are requirements and limitations sometimes imposed on slag which are not a measure of quality and should not be included in specifications:

1. *Abrasion.*—It has been definitely proven that the Deval abrasion test is not a satisfactory indication of the quality of slag.

2. *Chemical Composition.*—While the chemical composition of slag has a direct effect on its quality, yet the writing of definite requirements in specifications for certain chemical constituents is impractical. Blast-furnace slags, generally, are very uniform in chemical composition, as compared with other aggregates.

3. *Age.*—The age of slag is not in any way a measure of quality and should not be a specification requirement.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 750 (1931); also 1935 Book of A.S.T.M. Tentative Standards, p. 578.

APPENDIX III

STUDIES OF SODIUM AND MAGNESIUM SULFATE SOUNDNESS TESTS

By Stanton Walker[1] and C. E. Proudley[1]

Soundness is an important characteristic of aggregates for use in concrete exposed to destructive agencies. Engineers have seized avidly on any method of test which has promised to furnish some measure of the resistance of aggregates to weathering and other factors causing disintegration. In a great many cases, methods intended only as guides have been adopted as arbitrary bases of acceptance in purchase specifications, without sufficient knowledge of their significance or of the ability of laboratory operators to obtain results which can be duplicated.

Probably the best standardized and most widely accepted methods are the Tentative Method of Test for Soundness of Fine Aggregates by Use of Sodium Sulfate or Magnesium Sulfate (C 88 – 35 T)[2] and the Tentative Method of Test for Soundness of Coarse Aggregates by Use of Sodium Sulfate or Magnesium Sulfate (C 89 – 35 T)[2] of the American Society for Testing Materials. The procedures for the two methods are essentially the same; they provide for the alternate soaking and drying of aggregates under controlled conditions, using a saturated solution of sodium or magnesium sulfate as the soaking solution. They represent a summation of experience from somewhat scattered and uncorrelated studies of the use of salt solutions to simulate frost action carried out by many investigators since Brard's work reported in 1828.

In the "scope" of each of the two test methods it is stated: "It is recommended that the results obtained with this test method shall be considered only as a guide in the selection of aggregates. It is not intended that the test shall be used as an arbitrary basis for rejection of the material without taking other factors into account; consideration should be given to the results obtained with the material when exposed to actual weathering conditions." In spite of that warning, many purchasing bodies have adopted definite limits on the loss which an acceptable material may sustain in the tests. If the "loss" is barely within the limit, the material is considered as suitable, and if it is barely over the limit, it is rejected. Experiences with the sodium and magnesium sulfate tests have shown that, while results can be duplicated with reasonable accuracy under identical conditions, minor and unpredictable variations in conditions may affect the results in a very important degree.

This report describes some of the experiences of the National Sand and Gravel Association in the conduct of tests for soundness of aggregates using sodium and magnesium sulfate. The tests were made to furnish information on the effect of variations in procedure, which, in general, were within limits established in the Society's methods referred to above. Modifications of the test methods were also investigated to a limited degree. The work was done under the supervision of C. E. Proudley by George Crum, laboratory assistant, who has had considerable experience in making such tests. Little more supervision of the conduct of these tests was exercised than was customary for the usual routine determinations.

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[1] Director, Engineering and Research Division, and Research Engineer, respectively, National Sand and Gravel Assn., Washington, D. C.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, pp. 842 and 837, respectively (1935); also 1935 Book of A.S.T.M. Tentative Standards, pp. 608 and 603, respectively.

SCOPE

Data furnishing information on the following factors are included in this report:

1. Brand and grade of sodium and magnesium sulfate.
2. Degree of saturation of solutions.
3. Uniformity of tests made on different days.
4. Relation between tests with sodium and magnesium sulfate for different fine aggregates.

In addition to the fairly comprehensive data on those four factors, tests are summarized providing limited information on (*a*) effect of type of container, (*b*) effect of size of sample, (*c*) effect of completeness of drying, and (*d*) effect of conducting test with temperatures higher than 93 F. A small number of tests was also made using a procedure fundamentally different from that described in the Society's methods; the samples were kept in the soaking solution throughout the test and crystallization induced by changes in temperature.

MATERIALS AND TEST METHODS

One aggregate only was used for most of the tests—the smaller particles from a glacial gravel predominating in dolomitic particles. Except as noted, tests were made using either one of two sizes—material retained between standard sieves No. 8 and No. 4 or between No. 4 and ⅜-in. These sizes were selected for two reasons: first, it was felt that their use would eliminate much of the error in the sieving operations; second, the sizes are small enough so that each sample contained a sufficient number of particles to minimize variations due to mineral composition.

The aggregates for the tests were prepared by preliminary sieving in a foundry riddle, followed by twenty minutes of sieving of 110-g. samples in a Ro-tap testing machine using standard 8-in. diameter testing sieves. The prepared materials were thoroughly mixed, washed and dried and placed in a container from which all samples for any one group of tests were weighed.

Fourteen sodium sulfates and eight magnesium sulfates of various grades, marketed by two of the leading manufacturers, were used. Except where the different grades and brands were studied, the tests were made with a c. p. anhydrous sodium sulfate and a c. p. "dried powder" magnesium sulfate. Solutions were prepared using city water, except for the tests comparing different brands and grades of salt, when distilled water was used. In making the solutions, the salt was added, slowly and with constant stirring, to water having a temperature of 80 to 85 F. The mixture was thoroughly stirred and placed in a room maintained at a temperature of 70 ± 2 F.; further stirring was done at about 30-min. intervals for the first 3 or 4 hr. and at least twice daily thereafter. In no case were standard solutions used until 48 hr. after mixing. For the saturated solutions sufficient salt was added to insure an excess of crystals. The less-than-saturated solutions were obtained by diluting the saturated ones. The super-saturated solutions were obtained by quickly cooling to 70 F. a solution which had been saturated at 80 F. Specific gravity determinations were made on all solutions.

The tests were made strictly in accordance with the procedure of the Society's Methods C 88 – 35 T and C 89 – 35 T, using 100-g. samples of aggregate unless otherwise indicated. Except in special cases, the samples were soaked in white enameled pans without covers, using sufficient solution to cover the particles to a depth of about one inch. During the soaking period the pans were stored in a small room in which the temperature was controlled by an appropriate arrangement of an iced box, electrical heating coils, a thermostat, and a fan. The relative humidity of the air in the room was fairly uniform, within the range of about 75 to 85 per cent. The temperatures were recorded by a thermometer equipped with "24-hr." charts. In general, the temperature was maintained well within the range of 68 to 72 F. Departures from those limits were relatively few and generally of short duration. The samples were dried in a gas oven of a type used by bakers, having a considerable heat capacity, maintained by a thermostat at a temperature of 220 ± 4 F. All solution was decanted from the samples before drying.

TABLE I.—EFFECT OF BRAND AND GRADE OF SODIUM SULFATE.

Tests made in accordance with A.S.T.M. Methods C 88 - 35 T and C 89 - 35 T.
Solutions made with distilled water.
Fresh solution prepared for each of two runs.
Size of aggregate, No. 8 to No. 4.

Reference Number	Sodium Sulfate		First Run					Second Run					Average Loss
			Specific Gravity of Solution[a]		Loss in 5 Cycles, per cent			Specific Gravity of Solution[a]		Loss in 5 Cycles, per cent			
	Brand	Description	Before	After	Sample No. 1	Sample No. 2	Average	Before	After	Sample No. 1	Sample No. 2	Average	
		PURE GRADES											
59-1	A	C. P. (anhydrous)...	1.150	1.156	15.6	12.4	14.0	1.176	1.158	15.5	15.4	15.4	14.7
59-5	A	Low in nitrogen (anhydrous).........	1.154	1.158	12.7	14.7	13.7	1.160	1.156	12.7	15.0	13.8	13.8
59-6	A	For nitrogen determination (anhydrous)	1.154	1.156	14.8	13.7	14.2	1.160	1.156	15.9	15.6	15.8	15.0
59-13	A	Pure (dried powder).	1.156	1.156	14.3	12.9	13.6	1.166	1.158	12.5	13.4	13.0	13.3
59-10	A	C. P. (crystalline)...	1.160	1.154	10.8	14.0	12.4	1.160	1.156	23.8[b]	14.0	14.0	12.9
Average..	......	....	1.155	1.156	13.6	13.5	13.6	1.164	1.157	14.2	14.7	14.4	13.9
59-3	B	Reagent (anhydrous)	1.152	1.156	17.8	16.5	17.2	1.178	1.156	13.2	13.0	13.1	15.1
59-4	B	Free from nitrogen (anhydrous)......	1.152	1.156	13.6	11.9	12.8	1.160	1.158	14.9	12.8	13.8	13.3
59-14	B	Pure (dried powder).	1.156	1.154	13.4	13.5	13.4	1.166	1.156	13.9	13.0	13.4	13.4
59-9	B	Reagent(crystalline)	1.162	1.154	12.7	12.3	12.5	1.160	1.156	13.5	13.0	13.2	12.9
59-8	B	C. P. (crystalline)...	1.158	1.154	13.5	14.7	14.1	1.174	1.154	16.0	12.3	14.2	14.1
59-7	B	U. S. P. (crystalline)	1.156	1.154	14.3	14.3	14.3	1.162	1.156	15.1	13.4	14.2	14.3
Average..	......	....	1.156	1.155	14.2	13.9	14.1	1.167	1.156	14.4	12.9	13.7	13.9
Average—pure grades..................			1.155	1.155	14.0	13.7	13.8	1.166	1.156	14.3	13.7	14.0	13.9
		TECHNICAL GRADES											
59-2	A	Anhydrous..........	1.156	1.160	19.3	20.4	19.8	1.166	1.160	15.0	18.2	16.6	18.2
59-11	A	Crystalline..........	1.158	1.154	15.2	13.9	14.6	1.154	1.154	13.5	11.4	12.4	13.5
Average	....	....	1.157	1.157	17.3	17.2	17.2	1.160	1.157	14.3	14.8	14.5	15.9
59-12	B	Crystalline..........	1.108	1.156	14.4	13.1	13.8	1.170	1.156	12.2	16.6	14.4	14.1
Average—technical grades............			1.141	1.157	16.3	15.8	16.1	1.163	1.157	13.6	15.4	14.5	15.3
Grand average—all brands and grades.			1.152	1.156	14.5	14.2	14.3	1.165	1.156	14.1	14.1	14.1	14.2

[a] Before and after use in 5 cycles.
[b] Omitted from average.

DISCUSSION OF TESTS

This being a progress report, the data are summarized with only sufficient discussion to make clear their intent. No attempt has been made to draw specific conclusions as to exact relationships or to influence the reader's interpretation of the test results. However, the data do point to certain general conclusions.

Brand and Grade of Salt:

Tables I, II, and III give data showing results obtained with different brands and grades of sodium and magnesium sulfate. For the data in Tables I and II, two groups of tests were made, two samples being run at the same time for each group

TABLE II.—EFFECT OF BRAND AND GRADE OF MAGNESIUM SULFATE.

Tests made in accordance with A.S.T.M. Methods C 88 - 35 T and C 89 - 35 T.
Solutions made with distilled water.
Fresh solution prepared for each of two runs.
Size of aggregate, No. 8 to No. 4.

Reference Number	Sodium Sulfate		First Run					Second Run					Average Loss
			Specific Gravity of Solution[a]		Loss in 5 Cycles, per cent			Specific Gravity of Solution[a]		Loss in 5 Cycles, per cent			
	Brand	Description	Before	After	Sample No. 1	Sample No. 2	Average	Before	After	Sample No. 1	Sample No. 2	Average	
60-4	A	C. P. (crystalline)...	1.290	1.290	20.9	19.2	20.0	1.292	1.292	20.7	19.4	20.0	20.0
60-5	A	C. P. Special (crystalline)..........	1.288	1.288	22.9	21.2	22.0	1.290	1.290	17.4	19.9	18.6	20.4
60-1	A	U. S. P. (crystalline)	1.292	1.292	17.0	20.0	18.5	1.290	1.290	14.0	15.4	14.7	16.6
60-6	A	C. P. (dried powder)	1.290	1.290	25.4	23.2	24.3	1.292	1.290	24.4	24.0	24.2	24.2
Average..........			1.290	1.290	21.6	20.9	21.2	1.291	1.291	19.1	19.7	19.4	20.3
60-3	B	Reagent (crystalline)	1.260	1.260	19.4	21.9	20.6	1.260	1.262	18.7	18.0	18.4	19.5
60-2	B	U. S. P. (crystalline)	1.290	1.290	20.0	20.0	20.0	1.290	1.292	18.0	16.6	17.3	18.6
60-7	B	C. P. (dried powder)	1.290	1.290	19.8	23.0	21.4	1.290	1.292	19.4	18.3	18.8	20.1
60-8	B	Pure (dried powder).	1.290	1.290	25.1	24.4	24.8	1.292	1.290	24.4	25.0	24.7	24.7
Average..........			1.283	1.283	21.1	22.3	21.7	1.283	1.284	20.1	19.5	19.8	20.7
Grand Average..........			1.286	1.286	21.3	21.6	21.4	1.287	1.287	19.6	19.6	19.6	20.5

[a] Before and after use in 5 cycles.

TABLE III.—EFFECT OF GRADE OF SODIUM SULFATE.

Tests made in accordance with A.S.T.M. Tentative Method of Test for Soundness of Fine Aggregates by Use of Sodium Sulfate (C 88 - 32 T),[a] except that the solution was maintained at a temperature of 80 F.

Tests run simultaneously using saturated solutions of two different grades of anhydrous sodium sulfate—*pure* and *technical*.

Aggregate was sand of glacial origin consisting principally of sandstone, limestone, and quartz particles.

Salt	Grading of Sample, retained between sieves	Sieve Analysis After 5 Cycles, per cent retained on					Loss, per cent
		No. 100 Sieve	No. 50 Sieve	No. 30 Sieve	No. 16 Sieve	No. 8 Sieve	
Pure..........	No. 30 to No. 16	99.5	99.1	96.6	....	....	3.4
Technical..........		85.0	82.0	78.7	....	....	21.3
Pure..........	No. 8 to No. 4	98.0	97.4	97.0	95.8	89.5	10.5
Technical..........		83.0	81.3	80.0	78.7	69.1	30.9

[a] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 713 (1932); also 1934 Book of A.S.T.M. Tentative Standards, p. 484.

The "first run" was started early in March and the second late in April. The data in Table III are from tests run several years ago and, while not a part of this investigation, they furnish information pertinent to it.

Reference to Tables II and III will show that, in general, the variations in results for the different brands and grades of the "pure" salts were quite small—well within variations to be expected from repeated tests using the same salt. The "technical" grades of sodium sulfate gave somewhat higher results than the pure grades. The data in Table III afford another comparison of a "pure" and "technical" grade of sodium sulfate and show the latter to cause very much higher losses in the tests.

TABLE IV.—EFFECT OF DEGREE OF SATURATION OF SULFATE SOLUTIONS.

Tests made in accordance with A.S.T.M. Methods C 88 - 35 T and C 89 - 35 T, except that solutions were saturated as indicated.

Fresh solution made with city water prepared for start of each round of tests.

Size of aggregate, No. 4 to $\frac{3}{8}$ in.

Percentage Saturation of Solution	Loss After 5 Cycles, per cent						
	Test A	Test B	Test C	Test D	Test E	Test F	Average
SODIUM SULFATE							
50	4.4	3.8	3.7	4.1	2.2	7.2	4.2
70	7.9	7.8	8.0	7.4	3.0	2.9	6.2
90	10.4	12.2	11.4	10.9	6.1	8.5	9.9
95	....	....	16.4	17.1	16.5	11.3	15.3
100	....	....	16.4	17.1	15.4	14.4	15.8
100 (plus)	....	....	30.2	31.4	13.0[a]	11.0[a]	30.8
MAGNESIUM SULFATE							
50	7.9	7.7	7.4	6.9	1.7	3.4	5.8
70	11.4	11.7	10.1	10.0	12.3	10.4	11.0
90	15.1	14.2	14.4	15.1	14.7	13.4	14.5
95	....	....	19.7	20.2	17.5	5.0[b]	19.1
100	....	....	20.4	21.6	15.6	16.8	18.6
100 (plus)	....	....	30.4	29.2	13.2[a]	11.4[a]	29.8

[a] Omitted from average; super-saturated condition probably not maintained.

[b] Omitted from average.

TABLE V.—VARIATIONS IN TESTS MADE ON DIFFERENT DAYS.

Tests made in accordance with A.S.T.M. Methods C 88 - 35 T and C 89 - 35 T.

Solutions made with city water.

Date Started	Loss in 5 Cycles, per cent			
	Sodium Sulfate		Magnesium Sulfae	
	No. 8 to No. 4 Sieve	No. 4 to $\frac{3}{8}$-in. Sieve	No. 8 to No. 4 Sieve	No. 4 to $\frac{3}{8}$-in. Sieve
Dec. 2, 1935	....	13.1[a]	....	17.3[a]
Dec. 3, 1935	14.6	13.8	22.0	18.3
Dec. 4, 1935	13.4	12.2	20.6	....
Dec. 5, 1935	14.6	....	20.1	....
Dec. 17, 1935	....	14.4	13.4	12.7
Jan. 13, 1936	....	16.7[b]	....	21.0[b]
Jan. 29, 1936	....	11.7[b]	....	9.5[b]
Mar. 2, 1936	14.0[b]	....	24.3[b]	....
Mar. 16, 1936	....	14.9[b]	....	16.2[b]
Mar. 24, 1936	25.0	15.0	17.0	18.4
Mar. 25, 1936	23.2	15.2	13.5	17.4
Mar. 26, 1936	10.0	11.7	17.4	17.2
Mar. 27, 1936	17.9	18.7	30.7	29.7
Mar. 30, 1936	13.7	13.6	20.0	18.6
Mar. 31, 1936	15.2	16.0	19.2	19.5
Apr. 1, 1936	18.9	13.5	20.0	16.4
Apr. 2, 1936	14.3	16.6	21.0	16.5
Apr. 3, 1936	13.9	12.0	13.2	22.4
Apr. 4, 1936	10.9	8.7	....	....
Apr. 6, 1936	....	14.3[b]	....	17.9[b]
Apr. 24, 1936	15.4[b]	....	....	....
Apr. 27, 1936	....	....	24.2[b]	....
Average	15.7	14.0	19.8	18.1
Number of days	15	18	15	16
Average deviation from mean	3.0	1.8	3.3	2.7
Average deviation from mean, per cent	19.1	12.9	16.7	14.9
Standard deviation, per cent	24.9	15.7	22.8	23.2
Percentage of tests within 10 per cent of average	33.3	50.0	40.0	62.5
Percentage of tests within 20 per cent of average	66.7	88.8	60.0	75.0

[a] Average of 4 tests made on same day.

[b] Average of 2 tests made on same day.

The data in Tables I and II afford an opportunity to compare the differences in results obtained from two samples tested at the same time with the differences of two sets of tests made at different times. In general, variations between the two samples tested at the same time were greater than those between the averages of the two runs. In the case of sodium sulfate, the average of the differences between individual results for samples tested at the same time was 1.5, while the average of the differences between two tests made at different times was 1.2. In the case of the magnesium sulfate, the average of differences between the two tests made at the same time was 1.5, while the average of the differences between the two runs was 0.9.

It is of interest to point out that the specific gravities of all salt solutions were about the same after the 5 cycles had been run. That the fresh solution generally had a specific gravity differing from the solution after use indicates that the mixing and storage period before use (never less than 48 hr.) was not always sufficient to bring about a stable condition.

Chemical analyses of the salts were not made. For most of the "pure" grades analyses were reported by the manufacturer, but a study of them does not indicate them to be of sufficient significance to justify including them in this report.

Degree of Saturation of Solution:

The degree of saturation of the salt solution has a most important effect on the results of both sodium and magnesium sulfate tests. As Garrity and Kriege[1] have pointed out, great care needs to be exercised if an exactly saturated solution is to be obtained, and this is particularly true in the case of sodium sulfate. Not only must care be taken to allow sufficient time and to provide enough agitation to insure that the salt is dissolved, but the temperature must be carefully controlled after the solution is mixed. For example, in the case of sodium sulfate, a solution saturated at 68 F. is less than 90 per cent saturated when the temperature is raised to 72 F. As another example, consider a sodium sulfate solution saturated at 70 F. and the temperature allowed to drop to 60 F. Under most conditions some of the salt will crystallize out and there may be left in solution as little as 60 per cent of that required for saturation at 70 F. If the temperature is again raised to 70 F., considerable time and agitation are required to bring the crystallized salt back into solution. A similar action occurs in the magnesium sulfate solutions, although to a very much less degree.

To obtain some information on the effect of saturation of solution, a group of tests was made using solutions of 6 different degrees of saturation ranging from 50 per cent to a super-saturated condition. The data are given in Table IV. While they are not as concordant as could be wished, they show definite trends and demonstrate conclusively the important effect of degree of saturation. In the case of sodium sulfate, temperatures averaging 70 F. but fluctuating within the range of 68 to 72 F. could result in variations approximately as great as those shown for the 95 per cent and super-saturated solutions.

Daily Variations in Tests:

During the period from December 2, 1935, to April 27, 1936, individual tests were made on different days under the same conditions, using both sodium and magnesium sulfate, to determine what variations might be expected in routine repetitions of tests. The data are shown in Table V. As stated previously, the attempt was made, with good success, to control the soaking temperatures within the range of 68 to 72 F. The temperatures did get out of control on a few occasions, when the thermostat jammed, or the ice box became empty over a week end, or a heating element burned

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[1] L. V. Garrity and H. F. Kriege, "Studies of Accelerated Soundness Tests," *Proceedings*, Vol. 15, 1935, p. 237, Fifteenth Annual Meeting, Highway Research Board.

Table VI.—Accelerated Sodium Sulfate Tests of Six Samples of Sand from Same Source.

Two tests made on independent samples from the same lot of sand. The duplicate tests were carried out at the same time.

Tests made in accordance with A.S.T.M. Tentative Method of Test for Soundness of Fine Aggregates by Use of Sodium Sulfate (C 88 – 31 T)[a], except that the sodium sulfate solution was maintained at a temperature of 80 F.

Samples selected and tested at various times over a period of 10 months.

Test	Loss in 5 Cycles of Treatment of Each Size, per cent						Weighted Average Loss, per cent[b]
	No. 100 to No. 50 Sieve	No. 50 to No. 30 Sieve	No. 30 to No. 16 Sieve	No. 16 to No. 8 Sieve	No. 8 to No. 4 Sieve	No. 4 to No. 3 Sieve	
No. 1	3.3	10.6	9.3	9.8	9.4	18.6	9.44
No. 2	2.2	11.0	8.3	9.0	7.8	12.0	8.52
No. 3	5.4	7.2	11.4	9.0	11.4	24.4	9.81
No. 4	2.4	4.0	9.9	15.8	20.0	26.8	11.75
No. 5	4.9	7.6	8.6	10.9	14.6	20.6	10.08
No. 6[c]	1.2	1.6	5.0	10.0	10.4	[d]	6.48

[a] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 263 (1931); also 1931 Book of A.S.T.M. Tentative Standards, p. 769.

[b] Weighed according to average sieve analysis of all six samples.

[c] Test made of material sampled after certain changes in production method designed to reduce sodium sulfate loss.

[d] Sample did not contain any of this size. For purpose of computing weighted average loss shown in this tabulation an average of the previous 5 tests of this size was taken (20.5 per cent).

Table VII.—Summary of Soundness Tests of Fine Aggregates Using Sodium Sulfate and Magnesium Sulfate.

Tests made in accordance with the A.S.T.M. Tentative Method of Test for Soundness of Fine Aggregates by Use of Sodium Sulfate (C 88 – 32 T), except that both sodium and magnesium sulfate were used and sulfate solution was maintained at a temperature of 80 F.

Two tests were made with each salt on independent samples from the same lot of sand; comparative tests made at the same time and in duplicate.

Lot	Source	Weighted Average Loss, per cent	
		Sodium	Magnesium
No. 458	N. Y.	1.4	....
No. 490	N. Y.	1.4	....
No. 647	Mass.	1.8[b]	....
No. 542	D. C.	2.2	8.0
No. 614	N. Y.	2.2	5.7
No. 283-b	Iowa	2.8[a]	10.4[a]
No. 646	Mass.	3.0[b]	....
No. 589-96	S. C.	3.0	4.3
No. 645	Mass.	3.1[b]	....
No. 283-a	Iowa	3.2[a]	4.6
No. 283-c	Iowa	3.2[a]	8.4[a]
No. 769	Ohio	3.3[b]	....
No. 763	Ind.	3.4	....
No. 473	Ohio	3.4	....
No. 613	N. Y.	3.4	5.1
No. 474	Ohio	3.6	....
No. 627	Ind.	3.6[b]	....
No. 446	N. Y.	3.8	....
No. 565	Pa.	3.9	10.7
No. 444	Pa.	4.2	....
No. 454	N. Y.	4.2	....
No. 495	N. Y.	4.2	....
No. 518	N. Y.	4.2	12.3
No. 453	Pa.	4.4	....
No. 757	Mich.	4.4	....
No. 625	Ind.	4.6[b]	....
No. 765	Ohio	4.6	....
No. 571	Pa.	4.7	9.3
No. 607	N. Y.	4.8	19.2
No. 505	N. Y.	4.8	21.4
No. 615	Ohio	5.2	12.9
No. 752	Ohio	5.2	....
No. 434	N. Y.	5.3[b]	....
No. 437	N. Y.	5.4[b]	....
No. 744	Ohio	5.4	....
No. 574-9	S. C.	5.4	3.6
No. 530	N. Y.	5.8	12.3
No. 612	N. Y.	5.9	23.3
No. 701	N. Y.	5.9	....
No. 501	N. Y.	6.0	....
No. 572	Pa.	6.0	25.2
No. 749	Ind.	6.1	....
No. 737	Ohio	6.3	11.8[b]
No. 697	N. Y.	6.4[b]	12.7[b]
No. 759	Mich.	6.6	....
No. 761	Ind.	6.6	....
No. 747	Ohio	6.7	....
No. 529	N. Y.	6.7	13.8
No. 755	Ind.	7.2	....
No. 528	N. Y.	7.4	11.4
No. 531	N. Y.	7.6	16.7
No. 828	Ohio	8.0	....
No. 428	N. Y.	8.4[b]	....
No. 657	N. Y.	8.5	25.0
No. 566	Pa.	9.4[c]	32.2
No. 445	N. Y.	9.5	....
No. 426	N. Y.	9.9[b]	....
No. 455	Pa.	9.9	....
No. 736	Ohio	10.0	19.7[b]
No. 658	N. Y.	10.3	23.9
No. 735	Ohio	10.6	21.9[b]
No. 826	Ohio	10.6	....
No. 468	N. Y.	10.8	....
No. 827	Ohio	11.3	....
No. 655	N. Y.	11.5	25.1
No. 447	N. Y.	12.0	....
No. 817	Ohio	13.4[b]	....
No. 451	N. Y.	14.6	....
No. 656	N. Y.	15.0	24.9
No. 438	Pa.	20.0	....

[a] Average of 3 tests.

[b] One test only.

[c] Average of one test of 5 cycles and another of 6 cycles.

out. In spite of the accuracy of control of conditions, it will be observed that the uniformity of the test results leaves much to be desired. The data are too few to permit of statistical studies, but a sufficient number of samples was tested to show that unusual precautions are required if reasonable uniformity is to be obtained.

It should be pointed out, however, that the variations obtained in these tests, where only one size was used, are greater than would be found for the weighted average in routine tests of a graded material where the results are based on losses for several sizes; in such tests a high value for one size is likely to be compensated for by a low value for another size.

Table VI furnishes additional information along these lines from a group of tests made several years ago. Results of tests of 6 samples, selected and tested at various times over a period of 10 months, are shown.

Sodium and Magnesium Sulfate Tests on Different Sands:

Table VII shows the results of routine tests on a number of fine aggregates carried out from time to time over a period of several years. The data are included in this report to give some information as to the range in values which may be expected for different sands and on the relationship between the results of sodium and magnesium sulfate tests. It will be observed that the magnesium sulfate tests practically always showed higher results than the sodium sulfate tests. It does not appear from the data to be feasible to establish a ratio showing the relation of one test method to the other.

Miscellaneous Tests:

A number of variables were studied for which the data are neither complete nor conclusive enough to justify reporting in detail. However, they suggest trends and point to factors on which it is evident that additional information should be obtained.

Tests were made in which the samples were stored in different types of containers during the soaking period. In addition to the white enameled pans used in all routine work and for the major portion of this investigation, sieves and cheese cloth bags were used. The data are erratic and sufficient tests were not made to provide convincing information as to what effect, if any, the types of containers had. However, for whatever value averages of erratic tests may be, the following results obtained with the different containers for two independent sets of tests are given, one started December 2 and the other April 6:

Type of Container	Loss After 5 Cycles, per cent					
	Sodium Sulfate			Magnesium Sulfate		
	Test No. 1	Test No. 2	Average	Test No. 1	Test No. 2	Average
Pan	13.1[a]	14.3[b]	13.7	17.3[a]	17.9[b]	17.6
Sieve	11.6[b]	9.0[b]	10.3	17.9[b]	14.1[b]	16.0
Sack	12.8[b]	4.4[b]	8.6	16.2[c]	5.1[c]	10.7

[a] Average of 4 tests.
[b] Average of 2 tests.
[c] One test only.

The effect of size of sample was studied using samples weighing 100, 200, 300, and 500 g. In this case, also, the results were not sufficiently uniform to point to conclusions, but they show trends indicating somewhat lower values for the larger samples. While it was intended that all samples be thoroughly dried between each cycle, it is probable that the low results for the larger samples were due to incomplete drying. Following are the average of two runs for both sodium and magnesium sulfate, each value being the average of 8 tests, 4 for each salt:

SIZE OF SAMPLE, G.	AVERAGE LOSS, PER CENT
100	14.1
200	13.2
300	13.0
500	7.8

Support for the thought that incomplete drying caused the lower results for the larger samples is found in some tests in which the drying was purposely incomplete. For each cycle, samples were dried for a period of about 1 to 1½ hr. until they *appeared* to be dry. An average of two sodium sulfate tests gave a loss of only 5.7 per cent after 5 cycles as compared with a normal loss of about 14 to 15 per cent, and an average of two magnesium sulfate tests gave a loss of 3 per cent as compared with the usual 18 to 20 per cent.

One group of tests was run for one cycle only, consisting of a 90-hr. soaking period and a 20-hr. drying period. The losses for this one cycle were 2.8 per cent for sodium and 4.5 per cent for magnesium sulfate. For each salt, two samples were run at the same time and gave practically identical results.

A group of tests was run for which all operations were carried out at temperatures above 93 F. The solution was saturated at about 95 F. and the soaking of the samples was done in an oven maintained at about 105 F. This procedure gave a loss in 5 cycles of 9.3 per cent for sodium sulfate and 6.4 per cent for magnesium sulfate. The reason for the lower-than-normal loss in the case of sodium sulfate seems clear, since the crystals were limited to the anhydrous form. The reasoning in the case of the magnesium sulfate is not quite so clear.

Because of the effect of temperature on the solubility of sodium and magnesium sulfate and the characteristic of sodium sulfate to form hydrous crystals at temperatures lower than about 93 F. and the anhydrous crystal at higher temperatures, tests were run in which the samples were not removed from the soaking solution, crystallization being induced by changes in temperature. The samples were placed in solution saturated at 70 F., using fruit jars as containers, and then raised to a temperature of 220 F. within a period of 1 hr. The immersed samples were then stored at room temperature in a current of air for 30 min. and then placed in ice water for 1 hr. After 30 min. in the ice water, if crystallization had not occurred, the formation of the crystals was induced by evaporation, agitation, or dropping a small crystal of salt into the solution. Five cycles of this treatment showed a loss in sodium sulfate of 5.3 per cent, and 10 cycles, 7.1 per cent. For magnesium sulfate, the loss was 1.9 per cent after 5 cycles, and about 5 per cent after 10 cycles.

CONCLUSION

The data outlined in this progress report indicate that the procedures outlined in A.S.T.M. Methods C 88 – 35 T and C 89 – 35 T are neither sufficiently definite nor restrictive to insure uniform test results. They lend support to the statement accompanying the test methods that results should be used only as a guide and not as an arbitrary basis for rejection. It seems clear that either the present methods should be surrounded with further restrictions or that another procedure, less sensitive to minor variations in technique, should be adopted. To do the first would make it difficult for the tests to be carried out as routine in the average laboratory. Particular attention should be paid to the latter alternative if testing engineers are to continue to use sodium and magnesium sulfate in accelerated soundness tests of aggregates.

DISCUSSION

MR. D. O. WOOLF[1] (*presented in written form*).—The basic thought underlying Walker and Proudley's report on the accelerated soundness test appears to be that exact compliance with all of the provisions of the test method is impracticable. This feature, as well as the results of it, are well demonstrated by the data accompanying the report. If, for example, it is so difficult to prepare and maintain a saturated solution of the sulfate salt, there is little wonder that the results so frequently show lack of agreement between duplicate tests. Messrs. Walker and Proudley recommend that the method of test either be made more specific and restrictive or be replaced by another procedure which would be less sensitive to minor variations in technique. The method as now specified is sufficiently difficult to follow to prevent the tests being made by other than the most skillful and experienced operator. And even when so made, past experience has shown that the results are frequently of questionable accuracy.

In the writer's opinion, there are seven features which must be controlled carefully to insure the attainment of a reliable test result in the accelerated soundness test. These are:

1. Preparation of the sample.
2. Preparation of the solution.
3. Maintenance of constant temperature during the immersion period.
4. Bringing the sample to complete dryness during the drying period.
5. Type of container.
6. Use of fresh solution.
7. Removal of all salt from the sample at the completion of the test.

Although the specifications comment definitely on the preparation of the test sample, it seems that the importance of this feature has been largely overlooked. In a recent series of check tests, laboratory A found a weighted average loss of 11.9 per cent, and laboratory B secured a loss of 16.2 per cent. In studying the cause of this difference it was found that operator B brushed his sieves lightly to remove grains of sand which were feebly held by the wire mesh, and added this sand to the test samples. The inclusion in the test sample of these grains of practically sieve size was apparently the cause of the higher loss for laboratory B. Repetition of the test with sand which did not contain sieve size particles gave losses of 12.5, 12.7, and 10.5 per cent, or an average of 11.9 per cent which agrees favorably with that for laboratory A.

Walker and Proudley comment at some length regarding the difficulty of securing a sulfate solution saturated at 70 F. That this feature is of considerable variance with discussions found in textbooks on chemistry is of great interest. For example, Getman and Daniels[2] state "when a saturated solution is cooled, every trace of solid solute being excluded, the excess of dissolved solid may not separate. When an ordinary crystal of the solute with a normal solubility is introduced, however, the extra dissolved material crystallizes out immediately." From this it would appear that if slightly more salt than that required for saturation at 70 F. were dissolved in water at 80 F. the solution cooled to 70 F. and a few crystals of the salt added, a saturated solution would be obtained immediately with precipitation of the excess salt. The fact that Walker and Proudley find that a period of 48 hr. may be insufficient to attain a stable condition possibly explains many of the non-constant test results obtained.

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[2] F. H. Getman and Farrington Daniels, "Outlines of Theoretical Chemistry," Fifth Edition (1931).

The maintenance of constant temperature during the immersion period has always been one of the most difficult features of the test method to follow. Walker and Proudley state that a solution of sodium sulfate saturated at 68 F. is less than 90 per cent saturated at 72 F. Then if the temperature fluctuates in this range, the solution will be less than saturated after the first drop to 68 F. because the crystallized salt will not re-enter solution without vigorous and extended agitation. To comply fully with the requirement that the solution be saturated at all times, one of three methods must be employed:

1. The temperature of the solution be kept constant.
2. The temperature decrease but not rise.
3. The solution be constantly agitated.

Of these, maintenance of constant temperature is probably the best, but if this cannot be obtained, recirculation of the solution through temperature regulating and resaturation devices must be used. In all probability reliable results will never be obtained from this method of test until special storage cabinets with adequate temperature-regulating devices are used.

The maximum effect of the sulfate solution will not be obtained unless the sample is brought to oven dryness after each immersion period. If the sample is dried only partially, the water present in the pores of the sample will reduce the amount of salt deposited in each pore during the second and each subsequent immersion period. As the amount of breakage is dependent on the amount of salt crystallizing in the pores of the sample, failure to dry the sample completely will lessen the loss in the test. Each laboratory should determine the time required to bring test samples to oven dryness, and use this drying period in all tests.

The type of container used will influence the results by affecting the time required to dry and to resaturate the sample. Some time ago the writer used small cloth bags about $1\frac{1}{2}$ in. wide and 4 in. long as containers for soundness samples of fine aggregate. After the second or third drying period, the crust of salt formed on the bags was so thick that the bags floated when replaced in the sulfate solution. This crust reduces the rate of resaturation of the sample to a marked extent and may have a considerable effect on the test result. The use of containers which permit rapid drying and resaturation is definitely indicated. Ordinary brass frame testing sieves, 6 or 8 in. in diameter, with No. 60 or No. 120 wire mesh, have been found quite satisfactory as containers for fine aggregate.

The specifications for the accelerated soundness test do not impose any limitations on the length of time a given amount of the sulfate solution may be used. Although definite information is not at hand, it is believed that if a solution of sulfate salt is used repeatedly, the solution will at length contain not only the sulfate but also carbonates and silicates dissolved from the materials under test. The effect of these additions to the test solution is not known. Although the effect, if any, may be small, the desire to obtain consistent and reliable results would indicate that some definite limit be placed on the repeated use of the solution. It has been observed in some laboratories that the solution was used indefinitely. As the stock supply became depleted, additional salt and water were added to the original solution. In some cases the solution was periodically filtered to remove suspended matter; in others the solution looked like coffee. The other extreme is shown by a recently proposed specification for concrete aggregates. This requires that a freshly prepared solution of the sulfate salt be used for each immersion period. Consideration of the various factors involved suggests that a given amount of solution could be used for five cycles of the test procedure with the addition of few impurities and without undue expense.

At the completion of the last drying period, the sample must be washed thoroughly. Particularly in the case of fine aggregate the salt may hold split particles together and, unless completely removed, these failed particles may not be detected in the final sieving to determine the loss. If sieves are used as containers, the washing can be completed in a few hours by nesting the sieves above a sieve bottom pan into which a stream of water is sent through a pipe soldered into the pan. The water rises through the nest of sieves and runs over at the top, thus keeping the samples in a steadily moving stream of water.

If the above features are followed, the least difficulty would be experienced in making the accelerated soundness test in accordance with the present specifications.

APPENDIX IV

SHRINKAGE OF HAYDITE AND SAND-GRAVEL CONCRETE

By F. E. Richart[1] and J. E. Keranen[2]

Outline of Tests

This paper describes a series of tests made to study the shrinkage of plain Haydite concrete as compared with that of ordinary sand-gravel concrete. Three types of mixture were used: "all-Haydite," made with fine and coarse Haydite aggregates; "sand-Haydite," made with Attica, Ind., sand and coarse Haydite aggregate; and "sand-gravel," made with Attica sand and gravel. The coarse aggregate was below ¾ in. maximum size and in all mixtures equal volumes of fine and coarse aggregate were used. Proportions of the mixes are expressed in terms of loose volume, measured at "stock pile" conditions of moisture content. The mixtures were made with a slump of about 6 in., except in series No. 2, where a 2-in. slump was used. All specimens were made in triplicate.

Four series of tests were made, as follows, using 4 by 8-in. cylinders:

Series No. 1.—All-Haydite, sand-Haydite and sand-gravel concrete; three mixtures, 1:4, 1:5 and 1:6; aggregates in stock-pile condition, 28-day curing.

Series No. 2.—All-Haydite concrete; 1:5 mixture; three moisture conditions of aggregate, stock-pile, oven-dried and soaked; 28-day curing.

Series No. 3.—All-Haydite concrete; five mixtures 1:3, 1:4, 1:5, 1:6 and 1:8; stock-pile aggregates, 28-day curing.

Series No. 4.—All-Haydite and sand-gravel concrete; 1:5 mixture, stock-pile aggregates; 3, 7, 14 and 28-day curing.

Properties of the Aggregates:

The fineness moduli of the several aggregates were as follows: fine Haydite 3.06; coarse Haydite, 6.08; sand, 2.96; and gravel, 6.05. The corresponding unit weights, at stock-pile conditions, by loose volumes, were as follows: fine Haydite, 50.1; coarse Haydite, 39.3; sand, 104.0; and gravel, 99.2 lb. per cu. ft.

The Haydite aggregates were furnished by the Western Brick Co., Danville, Ill., and contained initial moisture considered to represent stock-pile conditions. For use in series No. 2, one lot of these aggregates was oven-dried to constant weight, and another lot was soaked in water 24 hr. before use in concrete. Tests were made on the aggregates to determine initial absorption as well as the further absorption in 1 hr.; the total absorption was deducted from the moisture content, tabulated below, in calculating the water-cement ratio:

Mixed Aggregate	Condition	Unit Weight, lb. per cu. ft.	Moisture Content, per cent by weight		Absorption in 1 hr., per cent by weight
			Initial	After 1-hr. Immersion	
All-Haydite	Stock-pile	51.6	9.9	15.1	5.2
	Dry	....	0.0	11.2	11.2
	Soaked	....	23.2	23.2	0.0
Sand-Haydite	As received	87.2	3.5	5.6	2.1
Sand-gravel	As received	120.3	0.4	2.3	1.9

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[1] Research Professor of Engineering Materials, University of Illinois, Urbana, Ill.
[2] Former Graduate Student in Civil Engineering, University of Illinois, Urbana, Ill.

Making and Testing of Specimens:

The 4 by 8-in. cylinders used as test specimens were hand-mixed from materials which were proportioned by weight. They were made to produce a slump of about 6 in.; this, however, did not produce a constant workability, as the Haydite aggregates were harsh and did not respond readily to changes in water content. In general, to produce a 6-in. slump, the water-cement ratio of the Haydite mixture was made somewhat higher than that of the corresponding sand-gravel mixture. The concrete was placed in the molds and compacted in general accordance with standard A.S.T.M. procedure. For shrinkage measurements, a stainless steel machine screw was set in the center of each end of the cylinder during the process of molding. The outer ends of these screws were ground to a spherical surface and formed contact points for the micrometer dial gage used to measure changes in length.

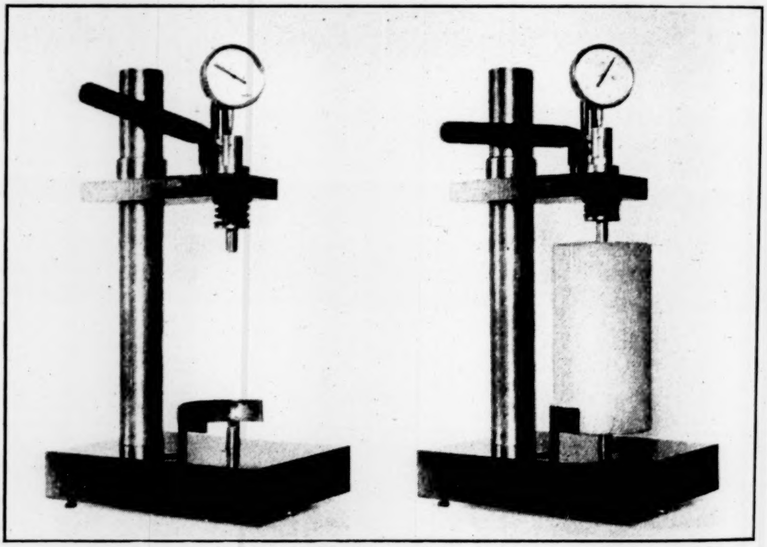

FIG. 1.—Views of Shrinkage Measuring Apparatus.

Figure 1 shows the general appearance of the test specimen and the measuring apparatus, which consisted essentially of a large Ames dial, reading to 0.0001 in., arranged with suitable contact points so that the specimen could be placed in exactly the same position for all measurements. The dial was calibrated by use of Johansson blocks and a range of travel was used which contained only a very slight mechanical error. A steel standard bar, not shown, was used to correct for accidental variations in the instrument.

The test specimens were cured in a moist closet at 70 F. for the period stated in the outline of the tests, then were placed in a small room and held at 70 F. and approximately 60 per cent relative humidity. Shrinkage measurements were taken once a day during the early stages of air storage, then the interval was gradually increased to a week. After the first 60 to 70 days, readings were taken only at the periods of 3 months, 8 months and 2 yr.

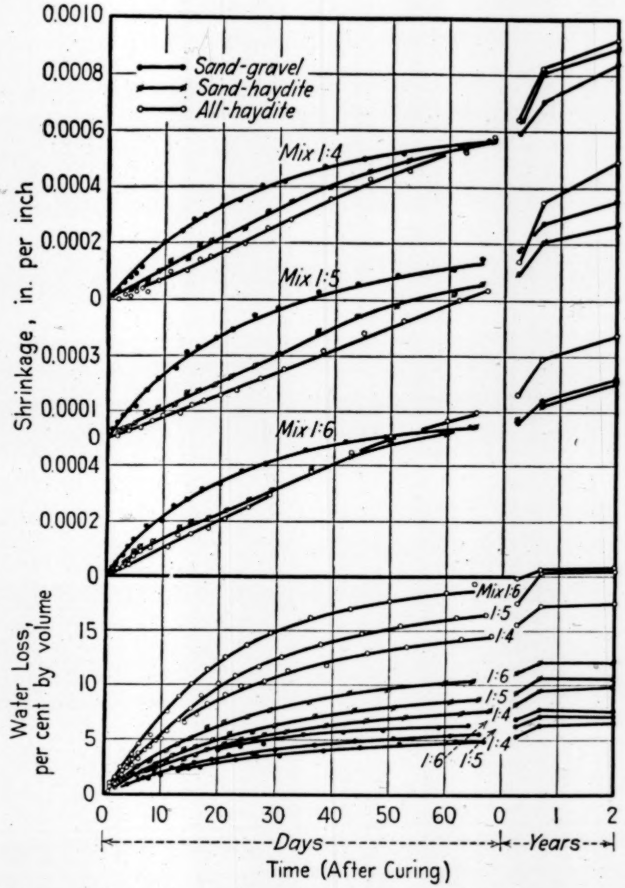

FIG. 2.—Effect of Kind of Aggregate on Shrinkage and Water Loss, Series No. 1.

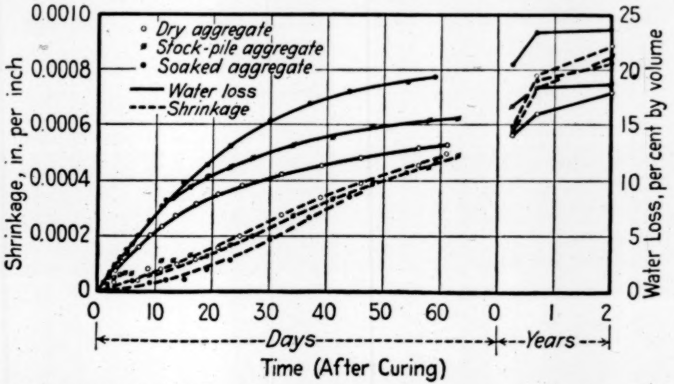

FIG. 3.—Effect of Initial Moisture Content of Haydite Aggregate on Shrinkage and Water Loss, Series No. 2.

Mixture 1:5; water-cement ratio, 0.81.

TEST RESULTS

Series No. 1:

Each of the following four figures contains representative curves for one of the four series of tests. Figure 2 shows for series No. 1 the relation between shrinkage, water loss and the period of time (immediately after moist curing) in which the specimens were measured. The curves present the test data for three concrete mixes, 1:4, 1:5, and 1:6, of concrete made with all-Haydite, sand-Haydite and sand-gravel aggregates.

The curves for all three richnesses of mix show that for the first 2 months the sand-gravel concrete exhibited the greatest shrinkage, the all-Haydite concrete the least, and the sand-Haydite concrete an intermediate amount. Furthermore, the curves for the three materials are decidedly different in shape, and converge to about the same point at 55 to 75 days. The curve for sand-gravel concrete would be considered typical for ordinary concrete; that for all-Haydite concrete, however, is almost a straight line. The curves showing the amount of water lost by each kind of concrete are also quite different in appearance. The water loss by all-Haydite concrete is by far the greatest, that by the sand-gravel concrete least, and that for sand-Haydite concrete intermediate. The principal difference in the three sets of curves is in their slope during the first 30 days; after that period they become nearly parallel.

The shrinkage and water-loss curves of Fig. 2 lead to two observations: (1) The water loss from the Haydite concrete, being several times as great as from the sand-gravel concrete, must come partly from the hardened cement paste and partly from the absorbed water in the aggregate. (2) The reservoir of water in the Haydite aggregate apparently feeds moisture to the cement paste and thus retards its shrinkage at early ages.

The shrinkage of the three kinds of concrete is very nearly the same after a period of 60 to 70 days; however, the subsequent measurements at 3 months, 8 months and 2 yr. indicate slightly higher values of shrinkage for Haydite concrete. Thus from the 2-yr. values in Fig. 2, it is found that the shrinkage of all-Haydite concrete was about 15 per cent higher than that of sand-gravel, while the shrinkage of sand-Haydite and sand-gravel concrete was about equal. In this connection it should be noted that while with any given mixture, the cement content was practically the same for the three kinds of aggregates, the water-cement ratio used with all-Haydite concrete to produce a given slump was about 20 per cent greater than that used with sand-gravel concrete; for sand-Haydite concrete the ratio was about 7.5 per cent greater than for sand-gravel concrete. This increased water ratio might be expected to produce the above increase in shrinkage, regardless of the kind of aggregate, other conditions being equal.

Series No. 2:

The tests of series No. 2 were planned to show the effect of different initial moisture contents of the Haydite aggregate upon subsequent volume changes. In these tests a constant water-cement ratio was used, with allowances made for the different absorption rates of the dry, moist and soaked Haydite. Figure 3 shows values of shrinkage and water loss for one set of all-Haydite concrete specimens of this series. As might be expected, a much greater water loss occurred in connection with the soaked aggregate, but the shrinkage in this case was slightly less than that obtained with the aggregates used in a drier condition. Despite a wide difference in water loss for the three cases, the variation in shrinkage was negligible throughout the entire 2-yr. period. It may be concluded that the initial moisture content of the aggregate does not affect the ultimate shrinkage of the concrete.

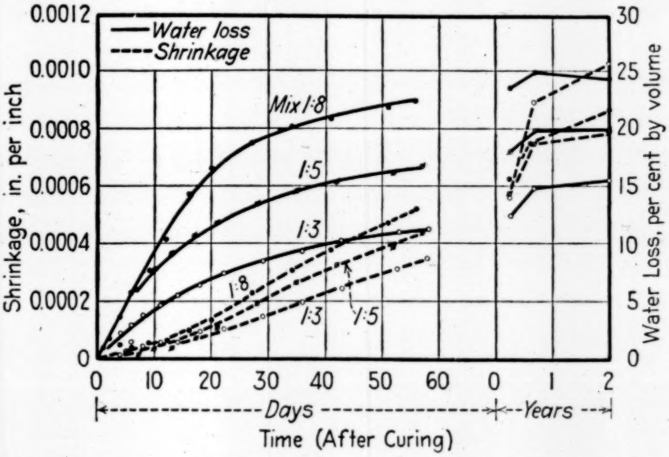

FIG. 4.—Effect of Richness of Mixture on Shrinkage and Water Loss of All-Haydite Concrete, Series No. 3.

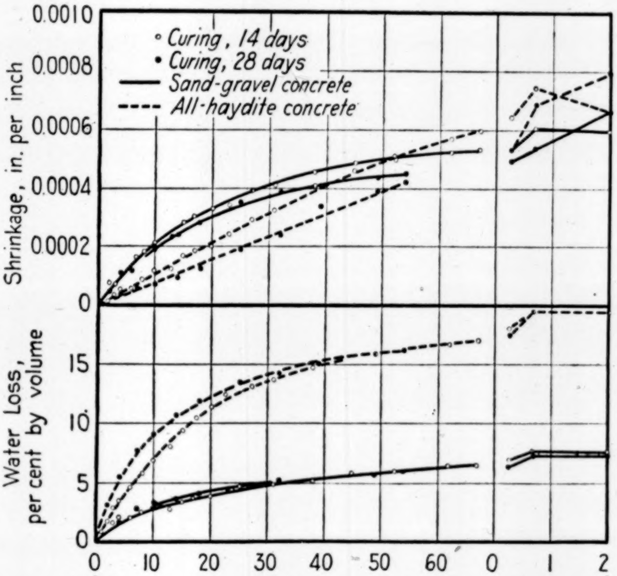

FIG. 5.—Effect of Different Periods of Moist Curing on Shrinkage and Water Loss, Series No. 4.

Mixture, 1:5.

Series No. 3:

Figure 4 presents a comparison of the shrinkage and water loss for rich, medium and lean all-Haydite concrete. It may seem surprising that at early periods the 1:8 mix shows the greatest shrinkage and the 1:3 concrete the least. While the rich material contained the most cement, it must also be kept in mind that the water-cement ratios for the three mixes were as follows: 1:3, 0.67; 1:5, 0.94; and 1:8, 1.45. The potential water loss was thus very much greater for the lean than for the rich mixes, and at early ages the water loss more than overbalanced the effect of cement content. However, the behavior of these concretes up to 2 yr. is interesting. The observations at 8 months showed that equilibrium in moisture content had practically been obtained and that the richer mix had taken the lead as to shrinkage; at 2 yr. this condition was even more definitely shown. The shrinkage values for the 1:5 concrete at all ages remain slightly lower than those for 1:8 concrete and this result is contrary to the action indicated by the 1:3 concrete. However, comparison of the results for 1:5 concrete with similar data of identical mixes used in series Nos. 1 and 2 indicate that the values for 1:5 concrete in Fig. 4 are unduly low and that substitution of the results from series Nos. 1 and 2 would produce consistent relations with the data for the 1:3 and 1:8 mixes.

TABLE I.—DATA OF CONCRETE MIXTURES.

Fine and coarse Haydite from Western Brick Co., Danville, Ill.
Sand and gravel from Wabash River pits, Attica, Ind.
Universal-Atlas portland cement.

Series	Aggregate	Mix, by volume	Slump, in.	Water-Cement Ratio, by volume[a]	Unit Weight of Fresh Concrete, lb. per cu. ft.	Moist Curing Period, days	Moisture Condition of Aggregate
No. 1	All-Haydite	1:4	6.4	0.86	97.4	28	Stockpile or as received
	Sand-Haydite	1:4	5.6	0.74	120.2		
	Sand-gravel	1:4	7.0	0.72	148.9		
	All-Haydite	1:5	6.1	0.94	96.1		
	Sand-Haydite	1:5	5.6	0.89	117.5		
	Sand-gravel	1:5	6.0	0.79	149.8		
	All-Haydite	1:6	6.1	1.19	93.0		
	Sand-Haydite	1:6	5.8	1.06	119.1		
	Sand-gravel	1:6	5.1	0.97	148.2		
No. 2	All-Haydite	1:5	2.0	0.81	98.7	28	Stockpile
	All-Haydite	1:5	...	0.81	94.3	28	Dry
	All-Haydite	1:5	...	0.81	102.1	28	Soaked
No. 3	All-Haydite	1:3	6.8	0.67	101.4	28	Stockpile
	All-Haydite	1:5	6.9	0.94	97.4		
	All-Haydite	1:8	6.6	1.45	94.1		
No. 4	All-Haydite	1:5	6.2	0.88	95.0	28	Stockpile or as received
	Sand-gravel	1:5	6.9	0.86	150.0	28	
	All-Haydite	1:5	6.3	0.88	94.8	14	
	Sand-gravel	1:5	6.9	0.86	149.2	14	

[a] Exclusive of absorbed water in aggregates.

It seems evident that in Haydite concrete, with the very large water losses (of which a part must come from the absorbed water in the aggregate) the usual relations between water loss and shrinkage cannot be expected to obtain; however, after moisture equilibrium has been reached in the concrete, the relative volume changes of various mixes may correspond better with values for ordinary concrete.

The estimated ratio of cement paste to volume of concrete is, for 1:3 concrete, 0.40; for 1:5, 0.33; and for 1:8, 0.30. This takes no account of the water in the aggregate. It indicates that the shrinkage of the 1:3 concrete should be considerably greater than that of the 1:8 concrete.

Series No. 4:

The shrinkage and water loss of 1:5 all-Haydite and sand-gravel concrete after curing periods of 14 and 28 days are shown in Fig. 5. It appears that the shrinkage of both kinds of concrete is a little greater, and the water loss less, for 14-day curing than for 28-day curing. Data are not given for shorter curing periods because of poor bonding of contact points at 3 and 7 days, with consequent unreliability of the results.

Data on the slumps, water-cement ratios and unit weights of concrete for the specimens of Figs. 2 to 5 are given in Table I.

SUMMARY

The characteristic differences between Haydite and sand-gravel concrete as regards shrinkage and water loss may be summarized as follows:

1. When stored in air at 70 F. and 60 per cent relative humidity, the Haydite concrete showed extremely high water losses and relatively low shrinkage for the first two months; after 2 yr. storage the shrinkage of all-Haydite concrete slightly exceeded that of sand-gravel concrete, as previously noted. This may be partly due to the fact that the water-cement ratio of the all-Haydite concrete was higher than that of the sand-gravel concrete, though they were both made to produce a 6-in. slump.
2. The shrinkage-time curves for all-Haydite concrete for the first 2 months were nearly straight lines, indicating a delayed or inhibited shrinkage due to the presence of a large amount of absorbed water.
3. The initial moisture content of the Haydite aggregate had little effect on the shrinkage of the concrete during the 2-yr. period.
4. Due to a very large water content, the lean Haydite concrete showed more shrinkage than the richer mixtures at early ages; however, at the end of 2 yr., the richer mixture showed the greater shrinkage, the value for 1:3 concrete being 19 per cent greater than that of the 1:8 concrete. The estimated cement-paste ratio of the 1:3 concrete was one-third greater than that for the 1:8 concrete.
5. Only minor differences were observed between the shrinkage and water loss of concretes that had been moist cured 14 and 28 days.
6. The initial absorbed water in Haydite aggregate, and that absorbed during curing, may form a large part of the water content of the concrete, and will affect the water lost in air storage. Haydite concrete thus does not follow the usual relation between water loss and shrinkage.

REPORT OF COMMITTEE C-10

ON

HOLLOW MASONRY BUILDING UNITS

Since the 1935 annual meeting of the Society, Committee C-10 on Hollow Masonry Building Units has held one meeting at Washington, D. C., on March 17, 1936. The present membership of the committee is 30, of whom 13 are classed as producers, 3 as consumers, and 14 as general interest members.

During the year Committee C-10 presented to the Society through Committee E-10 on Standards proposed revisions of the Tentative Specifications for Structural Clay Load-Bearing Wall Tile (C 34 – 35 T) and of the Tentative Methods of Sampling and Testing Structural Clay Tile (C 112 - 35 T). The specifications and methods in their revised form were accepted for publication[1] by Committee E-10 at a meeting held on August 22, 1935, and appear in the 1935 *Proceedings*.[2]

In the past year the committee has confined its attention chiefly to problems relating to structural clay tile. Consideration has been given to proposed revisions of the methods of capping tile for compression tests. Proposals to use capping materials of high strength so that the results of compression tests would give closer estimates of the actual strengths have been rejected for the time being because of the lack of suitable information on the relation between the properties of masonry and the apparent strengths of units when tested with these materials. It seems desirable, moreover, to require the use of methods of capping which are suitable for all types of tile, including shapes used for headers and stretchers.

The designations for tiles of different classes have been criticized by producers because of the tendency of consumers to require products of the highest class, and by consumers because the designations do not give a clear indication of the intended uses. Various methods of designation have already been used in standards for structural clay tile, but all of them seem to have elicited the same criticisms. The committee now proposes designations believed to be more descriptive of the intended use of the products and, in addition, is proposing the insertion of descriptions which will help to define the use.

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[1] In submitting these recommendations to Committee E-10 on Standards, Committee C-10 reported the following results of the letter ballot vote of a total of 27 ballots returned from a committee membership of 31: Specifications C 34, affirmative 23, negative 3, ballots marked "not voting" 1; Methods C 112, affirmative 26, negative 0, ballots marked "not voting" 1.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, pp. 803 and 807 (1935); also 1935 Book of A.S.T.M. Tentative Standards, pp. 509 and 513.

Another problem, which has been before the committee for several years, is the selection of the most effective method of limiting the shapes of tile to those that will serve the intended purpose. Two different methods were considered when the first specifications were prepared and after much consideration it was decided to place limits on the minimum weights of tile rather than to limit the dimensions and arrangement of shells and webs. Criticism of the present weight requirements, however, has again focused the attention of the committee on this problem, and a proposal to substitute dimensional and shape requirements for load-bearing tile was considered but failed to receive approval of the committee by letter ballot.

RECOMMENDATIONS AFFECTING STANDARDS

Adoption of Tentative Standards as Standard:

The committee recommends the submission of the following tentative standards to letter ballot of the Society for adoption as standard:

Tentative Specifications for Structural Clay Load-Bearing Wall Tile (C 34 – 35 T),[1] revised as indicated below:

Section 2.—Change Paragraph (*a*) and the table of strength and absorption requirements to read as follows by the addition of the italicized material and the omission of that in brackets:

2. (*a*) According to results of physical tests, tile shall be classified as [5–16 and 16–25] *LB X and LB* on the basis of the following strength and absorption requirements:

Use	*Designation of* Class	Absorption,[a] per cent			Compressive Strength Based on Gross Area,[b] lb. per sq. in.			
					End-Construction Tile		Side-Construction Tile	
		Average of 5 Tests	Individual Maximum	Individual Minimum	Average of 5 Tests	Individual Minimum	Average of 5 Tests	Individual Minimum
Not restricted[c]........	*LB X* [5–16]	5 to 16	19	4	1400 or more	1000	700 or more	500
Where not exposed to frost action[d]........	*LB* [16–25]	*5 to* 25 [or less]	28	4	1000 or more	700	700 or more	500

[a] *The range in percentage absorption for tile delivered to any one job shall be not more than 12.*

[b] Gross area of a unit shall be the total area of a section including cells perpendicular to the direction of loading. Re-entrant spaces are included in the gross area, unless these spaces are to be occupied in masonry by portions of adjacent units.

[c] *Tile classed as LB X shall be considered to be suitable for general use in masonary construction and to be especially adapted for use in masonry exposed to severe weathering provided they are burned to the normal maturity for the clay. They shall also be considered suitable for the direct application of stucco. Tile of class LB X shall be accepted under all conditions in lieu of tile classed as LB.*

[d] *Tile classed as LB shall be considered as being suitable for general use in masonry where not exposed to frost action or for use in exposed masonry where protected with a facing of 3 in. or more of stone, brick, terra cotta, or other masonry.*

Omit Paragraph (*c*) of Section 2, which reads as follows, and reletter the present Paragraph (*d*) as (*c*):

(*c*) Where tile is used in interior construction or as back-up for exposed walls with a facing of 3 in. or more of stone, terra cotta, brick or other facing, the requirements for average and individual maximum absorption shall be waived unless otherwise specified by the purchaser.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 803 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 509.

Section 3 (a).—Revise the tabulation by the omission of the requirements for maximum average weight expressed in pounds per square foot of tile.

Section 5.—Omit this section which reads as follows, renumbering the subsequent sections accordingly:

> 5. *Weathering Resistance.*—All tile which will be subjected to weathering conditions or intended to be stuccoed shall be able to withstand 100 alternate freezings and thawings. Tile classed as 5–16 by these specifications may be considered as meeting the weathering requirements, provided they are burned to a normal maturity for the given clay. Tile classed as 16–25 shall be accepted as meeting the weathering requirements only on the basis of freezing-and-thawing tests.

Tentative Specifications for Structural Clay Non-Load-Bearing Tile (C 56 – 35 T),[1] revised as indicated below:

Section 2.—Change to read as follows by the addition of the italicized material and the omission of that in brackets:

> 2. [According to results of physical tests,] *Non-load-bearing* tile shall be [classified as 5–16 and 16–25 on the basis of] *designated NB and shall comply with* the following absorption requirements:

		Absorption,[a] per cent		
Class]	*Designation of Class*	Average of Five Tests	Individual Maximum	Individual Minimum
[5–16]		[5 to 16]	[19]	[4]
[16–25]	*NB*	[16 to 25] *5 to 25*	28	4

[a] *The range in percentage absorption for tile delivered to any one job shall be not more than 12.*

Section 3.—Revise the tabulation by the omission of the requirements for maximum average weight expressed in pounds per square foot of tile.

Change the second sentence of the footnote to the table in Section 3 to read as follows by the addition of the italicized words and the omission of those in brackets:

> If any of the faces are [smooth], *unscored* the weights shall be increased 0.5 lb. per square foot of [smooth] *unscored* area.

New Section.—Add a new section as Section 5 to read as follows, renumbering the subsequent sections accordingly:

> 5. *Fireproofing Tile.*—(*a*) Tile intended for use in fireproofing structural members shall be of such sizes and shapes that they can be erected to cover completely the exposed surfaces of the members.
>
> (*b*) Fireproofing tile intended for use in non-load-bearing masonry shall conform to the requirements of these specifications. Fireproofing tile intended for use in load-bearing masonry shall conform to the Standard Specifications for Structural Clay Load-Bearing Wall Tile (A.S.T.M. Designation: C 34) of the American Society for Testing Materials.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 800 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 506.

Tentative Specifications for Structural Clay Floor Tile (*C 57 – 35 T*),[1] revised as indicated below:

Section 2.—Change Paragraph (*a*) and the table of strength and absorption requirements to read as follows by the addition of the italicized material and the omission of that in brackets:

2. (*a*) According to the results of physical tests, tile to be used in flat or segmental arches or used to resist stresses in combination tile and concrete ribbed slab construction, shall be classified as [5–16] *FT1* and [16–25] *FT2* on the basis of the following strength and absorption requirements:

Designation of Class	Absorption,[a] per cent			Compressive Strength Based on Net Area,[b] lb. per sq. in.			
				End-Construction Tile		Side-Construction Tile	
	Average of 5 Tests	Individual Maximum	Individual Minimum	Average of 5 Tests	Individual Minimum	Average of 5 Tests	Individual Minimum
[5-16] *FT1*	[5 to 16] *5 to 25*	[19] *25*	4	3200 or more	2250	1600 or more	1100
[16-25] *FT2*	[25 or less] *5 to 25*	[28] *25*	4	2000 or more	1400	1200 or more	850

[a] *The range in percentage absorption for tile delivered to any one job shall be not more than 12.*

[b] Net area of a unit shall be taken as the area of solid material in shells and webs actually carrying stresses in a direction parallel to direction of loading.

Section 3 (*b*).—Change the second sentence of the footnote to the table to read as follows by the addition of the italicized words and the omission of those in brackets:

If any of the faces are [smooth] *unscored,* the weights shall be increased 0.5 lb. per square foot of [smooth] *unscored* area.

Tentative Specifications and Tests for Load-Bearing Concrete Masonry Units (*C 90 – 34 T*),[2] revised editorially, as follows:

Section 3.—Change Paragraph (*c*) to read as follows by the addition of the italicized material:

(*c*) The average percentage of moisture in the units at time of delivery shall not exceed 40 per cent of the total absorption of the units when calculated as described in Sections 25 (b) *and* (*c*).

Section 14.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

14. Five full-size units shall be used. The units shall be in an air-dry condition equivalent to that [obtained by a period of seven days' protection from the weather at room temperature at from 60 to 80 F.] *required by Section 3* (*c*).

Sections 15 to 18.—Rearrange these sections so that they will appear in the following order: Section 15, Position of Unit; Section 16, Capping; Section 17, Speed of Testing Machine; Section 18, Bearing Block.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 796 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 502.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, p. 772 (1934); also 1935 Book of A.S.T.M. Tentative Standards, p. 498.

Tentative Methods of Sampling and Testing Structural Clay Tile (*C 112-35 T*),[1] revised as indicated below:

Section 8.—Change Paragraph (*a*) to read as follows by the addition of the italicized words:

> 8. (*a*) The weight per unit area of a tile specimen shall be calculated by dividing the total weight in pounds by the average area ***in square feet*** of the two faces of the tile as laid in the masonry.

Section 10.—Change the second sentence of Paragraph (*a*) to read as follows by the omission of the words in brackets:

> A quantity of plastic mortar made of a mixture of [three parts (by volume) of portland cement and one part of] unretarded gypsum (plaster of Paris) mixed with sufficient water to spread evenly shall be placed on a plane surface which has been coated with oil.

Change Paragraphs (*c*) and (*d*) to read as follows by the addition of the italicized words and the omission of those in brackets:

> (*c*) When specimens have [irregular] ***portions of*** bearing surfaces *in different planes,* [they shall be brought approximately to the same horizontal planes] *these surfaces shall be made plane and approximately parallel* by means of [steel bearing plates not less than ½ in. in thickness set in capping mortar, mixed as specified in Paragraph (*a*) with bed joints not more than ⅛ in. in average thickness] *a filling of mortar composed of one part by weight of a quick-hardening cement, conforming to the Tentative Specifications for High-Early-Strength Portland Cement* (*A.S.T.M. Designation: C 74 – 30 T*) *of the American Society for Testing Materials, and two parts of sand. The filling shall be aged for one day after which the specimens shall be capped as specified in Paragraph* (*a*).

> (*d*) *The* [cement] gypsum capping shall be aged at least [3] *2* days before the specimens are tested. [If the tests must be made sooner, the specimens may be capped with a neat mortar of unretarded gypsum. Gypsum caps shall be aged at least 1 hr. before the specimens are tested. If the specimens tested with gypsum caps fail to meet the strength requirements, other specimens from the same lot shall be tested with the cement-gypsum caps aged at least 3 days.]

Tentative Definitions of Terms Relating to Structural Clay Tile (*C 43-33 T*),[2] without revision.

The recommendations appearing in this report have been submitted to letter ballot of the committee, which consists of 31 members; 23 members returned their ballots, the results being as follows:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 807 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 513.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 682 (1933); also 1935 Book of A.S.T.M. Tentative Standards, p. 517.

Items	Affirmative	Negative	Ballots Marked "Not Voting"
ADOPTION OF TENTATIVE STANDARDS AS STANDARD			
Specifications and Tests for Load-Bearing Concrete Masonry Units (C 90 - 34 T), editorial revision	21	0	2
Specifications for Structural Clay Load-Bearing Wall Tile (C 34 - 35 T):			
Approval of revisions	23	0	0
Adoption as standard	20	1	2
Specifications for Structural Clay Non-Load-Bearing Tile (C 56 - 35 T):			
Approval of revisions	22	1	0
Adoption as standard	20	1	2
Specifications for Structural Clay Floor Tile (C 57 - 35 T):			
Approval of revisions	22	1	0
Adoption as standard	20	1	2
Methods of Sampling and Testing Structural Clay Tile (C 112 - 35 T):			
Approval of revisions	21	1	1
Adoption as standard	20	0	3
Definitions of Terms Relating to Structural Clay Tile (C 43 - 33 T)	20	1	2

The election of officers for the ensuing term of two years resulted in the selection of J. W. Ginder as vice-chairman and the re-election of D. E. Parsons and F. E. Emery as chairman and secretary, respectively.

This report has been submitted to letter ballot of the committee, which consists of 30 members; 26 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

D. E. PARSONS,
Chairman.

F. E. EMERY,
Secretary.

REPORT OF COMMITTEE C-18

ON

NATURAL BUILDING STONES AND SLATE

Committee C-18 on Natural Building Stones and Slate, since the presentation of its previous report at the 1932 annual meeting of the Society, has held but two meetings, one in Washington, D. C., on April 30, 1936, and the other in Atlantic City, N. J., in connection with this annual meeting. The committee has been practically inactive during the intermediate three-year period owing to continued changes in business personnel resulting from the industrial conditions, causing a loss of members and a temporary disrupting of the committee's plans.

Until recently, the personnel of the committee had been reduced to 12 members, classified as 3 producers, 5 consumers and 4 general interests; in addition there were 2 advisory members.

Quite recently, owing to similar conditions prevailing in Committee D-16 on Slate, and to the fact that the fields of work of that committee and of Committee C-18 are quite similar, it was decided by the Executive Committee of the Society that it would be well to combine the activities of that committee with the work of Committee C-18. Committee C-18 is accordingly undertaking the work that had previously been under the jurisdiction of Committee D-16 on Slate with the exception of those portions of the Slate Committee's program that have to do with the electrical properties of slate. The title of the committee has accordingly been changed to Committee C-18 on Natural Building Stones and Slate.

After the merger of activities and personnel, Committee C-18 now has a membership of 19 members, classified as follows: 4 producers, 8 consumers and 7 general interests. This reveals a lack of producer-interest representation and an effort will be made to obtain additional members in this classification. It is not the intention of the committee officers, including subcommittee chairmen, however, to await the results of this membership work but to proceed as rapidly as possible on those portions of its program on which projects have been started and on which considerable work has already been done.

RECOMMENDATIONS AFFECTING STANDARDS

In addition to the eight tentative methods of test for which Committee C-18 is responsible, the following standards prepared by the former Committee D-16 on Slate have now been placed under its jurisdiction:

Standard Method of Test for Water Absorption of Slate (D 221 – 31),
Standard Methods of Flexure Testing of Slate (Modulus of Rupture, Modulus of Elasticity) (D 222 – 31), and
Standard Definition of the Term Slate (D 247 – 27).

Since these are already standards of the Society they will require no immediate attention on the part of this committee, or until recommendations for their reconsideration or amendment may be presented to the committee.

The Tentative Methods of Test for Determining the Electrical Insulating Qualities of Slate (D 273 – 27 T), which were also prepared by Committee D-16, have been placed under the jurisdiction of Committee D-9 on Electrical Insulating Materials since they deal with insulating properties of slate.

Continuation of Tentative Standards as Tentative.—The eight methods of test for building stone prepared by this committee have been standing as tentative for from four to six years. At a previous meeting of the committee it was decided that the Tentative Method of Tension Testing of Natural Building Stone (C 103 – 32 T) should be reviewed by reason of certain questions that have been raised with regard to the size and form of specimens provided for in the method. It has been decided to allow the Tentative Method of Compression Testing of Natural Building Stone (C 98 – 30 T) to remain as tentative for a while longer in view of similar questions raised respecting this method so that this question may be given the desired consideration. Since the latter may in a minor way affect the dimensions in the cutting diagram of the "sampling procedure" of the Tentative Method of Sampling Natural Building Stone and Sample for Testing (C 101 – 32 T), it has been decided to continue this also as tentative, these decisions being confirmed by a majority vote of the committee by letter ballot. The committee at its meeting on July 1, 1936, voted to continue the Tentative Definitions of Terms Relating to Natural Building Stone (C 104 – 31 T) as tentative.

Adoption of Tentative Standards as Standards.—Since the remaining four tentative standards, the titles of which are given below, have not been questioned in any essential particular, and such minor criticisms that have been received by the committee having already been taken care of by editorial changes, the committee believes that they are now eligible for adoption as standard and accordingly recommends that they be approved for reference to letter ballot of the Society for adoption.

Tentative Methods of Test for Absorption and Apparent Specific Gravity of Natural Building Stone (C 97 – 31 T),[1]
Tentative Method of Flexure Testing of Natural Building Stone (Determination of Modulus of Rupture) (C 99 – 31 T),[1]

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, pp. 832, 829 (1931); also 1935 Book of A.S.T.M Tentative Standards, pp. 466, 472.

Tentative Method of Test for Modulus of Elasticity of Natural Building Stone (C 100 – 31 T),[1] and
Tentative Method of Shear Testing of Natural Building Stone (C 102 – 31 T).[1]

The recommendations in this report have been submitted to letter ballot of the committee, which consists of 19 members; 13 members returned their ballots, the results being as follows:

Items	Affirmative	Negative	Ballots Marked "Not Voting"
ADOPTION OF TENTATIVE STANDARDS AS STANDARD			
Methods of Test for Absorption and Apparent Specific Gravity of Natural Building Stone (C 97 – 31 T)	12	0	1
Method of Flexure Testing of Natural Building Stone (Determination of Modulus of Rupture) (C 99 – 31 T)	11	0	2
Method of Test for Modulus of Elasticity of Natural Building Stone (C 100 – 31 T)	12	0	1
Method of Shear Testing of Natural Building Stone (C 102 – 31 T)	12	0	1

ACTIVITIES OF SUBCOMMITTEES

Subcommittee III on Testing Procedure has developed a form of test procedure for determining the values of abrasive hardness of stone and slate which will, at the next meeting, be presented to the committee for consideration as a proposed tentative standard. This procedure, in general, follows the practice now in use at the National Bureau of Standards.

Several other items on the committee's program have been given consideration, including the work assigned to Subcommittees VI on Terms and Definitions and VII on Anchorage and Anchorage Practice and plans have been made for active work on these projects during the year.

The program, or rather work done and under consideration by the former Committee D 16 on Slate, was reviewed and an outline of the work in hand prepared for consideration of the whole committee as an addition to its former program. The program, as thus amended, will in due course be submitted to the committee for acceptance by letter ballot vote.

In view of the wasteful practices and cost of furnishing commercial samples of building stone to architects, engineers, builders and others interested in building, and the lack of uniformity as to size and form, as well as general requirements and procedure governing the preparation of and submitting of commercial samples, the committee has considered it advisable to augment the present sampling procedure now covering only samples for purpose of tests, by the establishment of a series of standard samples for commercial use with architects, engineers, and builders, and for such other purposes for which samples of building stone and slate are regularly required and used. The committee now has before it for consideration a series of proposals in connection therewith which when further developed by its subcommittee will be presented to the main committee for consideration, approval and eventually submission to the Society for publication as tentative.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, pp. 834, 839 (1931); also 1935 Book of A.S.T.M. Tentative Standards, pp. 475, 486.

At a meeting of the committee on July 1, 1936, two new subcommittees were appointed as follows: Subcommittee VIII on Standardization of Commercial Samples and Subcommittee IX on Slate (General). The latter new subcommittee was appointed so that the slate division of the committee would have a subcommittee in which to originate and prepare recommendations to the committee with regard to requirements covering both structural and roofing slates. Any additional subcommittees that may be required to handle the proposals or projects pertaining specifically to slate will be appointed later on, if the need of these becomes evident.

The election of officers for the ensuing term of two years resulted in the selection of the following:

Chairman, W. M. Greig,
Vice-Chairman, T. I. Coe,
Secretary, H. S. Brightly.

This report has been submitted to letter ballot of the committee, which consists of 19 members; 16 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

W. M. GREIG,
Chairman.

H. S. BRIGHTLY,
Secretary.

REPORT OF COMMITTEE D-1

ON

PRESERVATIVE COATINGS FOR STRUCTURAL MATERIALS

Committee D-1 on Preservative Coatings for Structural Materials held a meeting on March 3, 1936, at the Hotel William Penn, Pittsburgh, Pa., in conjunction with the spring group meetings of A.S.T.M. committees.

Subsequent to the 1935 annual meeting, the committee presented to the Society through Committee E-10 on Standards proposed Tentative Specifications for Southern Yellow Pine Wood to be Used in Weather Tests of Paints. These were accepted for publication[1] by Committee E-10 at a meeting held on August 22, 1935, and have been included in the Tentative Specifications for Wood to be Used as Panels in Weather Tests of Paints and Varnishes (D 358 - 35 T) and appear in the 1935 *Proceedings*.[2]

Several of the subcommittees have been very active during the past year, with the result that detailed reports were presented by them to the committee.

Since the last annual meeting, 34 new members have been elected, 8 resignations have been accepted and 1 death reported, leaving a total membership of 207.

A special committee created to consider reorganization of this standing committee submitted a report, as appended hereto, containing recommendations on definition of scope, change of name and plan for establishing closer contact between the Advisory Committee and subcommittees. These recommendations will be considered and acted upon at the annual meeting of this standing committee.

The work of the active subcommittees during the past year has resulted in the committee making the following recommendations to be acted upon at the annual meeting:

I. Revisions are proposed for immediate adoption in four standard methods of test, and as tentative in one standard specification and one method of test.

II. Two tentative specifications are recommended for adoption as standard with revisions, six without revision, and two methods of test without revision.

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[1] In submitting these specifications to Committee E-10 on Standards, Committee D-1 reported results of the letter ballot vote as follows: Of a total membership of 182, 68 members returned their ballots, of whom 54 voted affirmatively, 0 negatively, and 14 marked their ballots "not voting."

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 895 (1935); also 1935 Book of A.S.T.M. Standards, p. 692.

III. One tentative revision of a standard specification is recommended for adoption as standard without further revision.

IV. Withdrawal is recommended of one tentative revision of an existing standard.

Recommendations Affecting Standards

In this report, recommendations affecting standards and tentative standards are noted in brief form below, together with the results of the letter ballot. These recommendations are explained in the reports of the subcommittees directly responsible for them.

I. Proposed Revisions of Standards.—The committee recommends for immediate adoption as standard revisions in the following methods of test and accordingly asks for the necessary nine-tenths vote at the annual meeting in order that these modifications may be referred to letter ballot of the Society for immediate adoption:

Standard Methods of Routine Analysis of Yellow, Orange, Red and Brown Pigments Containing Iron and Manganese (D 50 - 33), revised as proposed by Subcommittee VIII,

Standard Methods of Routine Analysis of Yellow and Orange Pigments Containing Chromium Compounds, Blue Pigments and Chrome Green (D 126 - 35), revised as proposed by Subcommittee VIII, and

Standard Method of Routine Analysis of Dry Cuprous Oxide (D 283 - 33), revised as proposed by Subcommittee VIII.

Standard Methods of Sampling and Testing Turpentine (D 233 - 33), revised as proposed by Subcommittee XII.

The committee further recommends that the revisions proposed in the following specification and method of test be accepted for publication as tentative:

Standard Specifications for Lithopone (D 208 - 26), as proposed by Subcommittee XV, and

Standard Methods of Sampling and Testing Shellac (D 29 - 33), as proposed by Subcommittee XIII.

II. Adoption of Tentative Standards as Standard.—The committee recommends that the following tentative specifications, with revisions, be referred to letter ballot of the Society for adoption as standard:

Tentative Specifications for High Zinc Sulfide Lithopone (D 385 - 34 T), revised as proposed by Subcommittee XV, and

Tentative Specifications for Zinc Sulfide (D 386 - 34 T), revised as proposed by Subcommittee XV.

The committee further recommends that the following tentative specifications and methods of test, without revision, be referred to letter ballot of the Society for adoption as standard:

Tentative Specifications for Titanium Dioxide (D 384 - 34 T), as proposed by Subcommittee XV, Tentative Specifications for Amyl Acetate (from Fusel Oil) (85 to 88 per cent Grade) (D 318 – 34 T), as proposed by Subcommittee XXV,

Tentative Specifications for Industrial 90 per cent Benzene (Benzol) (D 361 – 33 T), as proposed by Subcommittee XXV,

Tentative Specifications for Industrial Pure Toluene (Toluol) (D 362 – 33 T), as proposed by Subcommittee XXV,

Tentative Specifications for Industrial Xylene (Xylol) or Solvent Naphtha (D 364 – 33 T), as proposed by Subcommittee XXV,

Tentative Specifications and Tests for Tricresyl Phosphate (D 363 – 33 T), as proposed by Subcommittee XXV,

Tentative Method of Test for Tinting Strength of White Pigments or White Pigment Pastes (D 332 – 35 T), as proposed by Subcommittee VIII, and

Tentative Methods of Test for Mass Color and Tinting Strength of Dry Color Pigments or Pastes (D 387 – 35 T), as proposed by Subcommittee VIII.

TABLE I.—ANALYSIS OF LETTER BALLOT VOTE.

Items	Affirmative	Negative	Ballots Marked "Not Voting"
I. PROPOSED REVISIONS OF STANDARDS			
Methods of Routine Analysis of Yellow, Orange, Red and Brown Pigments Containing Iron and Manganese (D 50 – 33), immediate adoption	58	0	26
Methods of Routine Analysis of Yellow and Orange Pigments Containing Chromium Compounds, Blue Pigments and Chrome Green (D 126 – 35), immediate adoption	65	0	19
Method of Routine Analysis of Dry Cuprous Oxide (D 283 – 33), immediate adoption	57	0	27
Methods of Sampling and Testing Turpentine (D 233 – 33), immediate adoption	73	0	20
Specifications for Lithopone (D 208 – 26)	65	0	19
Methods of Sampling and Testing Shellac (D 29 – 33)	45	0	39
II. ADOPTION OF TENTATIVE STANDARDS AS STANDARD			
Specifications for High Zinc Sulfide Lithopone (D 385 – 34 T), as revised	64	0	20
Specifications for Zinc Sulfide (D 386 – 34 T), as revised	65	0	19
Specifications for Titanium Dioxide (D 384 – 34 T)	65	1	18
Specifications for Amyl Acetate (from Fusel Oil) (85 to 88 per cent Grade) (D 318 – 34 T)	41	1	42
Specifications for Industrial 90 per cent Benzene (Benzol) (D 361 – 33 T)	47	0	37
Specifications for Industrial Pure Toluene (Toluol) (D 362 – 33 T)	48	0	36
Specifications for Industrial Xylene (Xylol) or Solvent Naphtha (D 364 – 33 T)	47	0	37
Specifications and Tests for Tricresyl Phosphate (D 363 – 33 T)	39	0	45
Method of Test for Tinting Strength of White Pigments or White Pigment Pastes (D 332 – 35 T)	68	0	16
Methods of Test for Mass Color and Tinting Strength of Dry Color Pigments or Pastes (D 387 – 35 T)	69	0	15
III. ADOPTION OF TENTATIVE REVISION OF STANDARD AS STANDARD			
Methods of Routine Analysis of Yellow and Orange Pigments Containing Chromium Compounds, Blue Pigments and Chrome Green (D 126 – 35)	64	0	20
IV. WITHDRAWAL OF TENTATIVE REVISION OF STANDARD			
Definitions of Terms Relating to Paint Specifications (D 16 – 24)	59	2	23

III. Adoption of Tentative Revision of Standard as Standard.—The committee recommends that the tentative revision proposed last year in the following standard, be referred to letter ballot of the Society for adoption as standard:

Revision of Standard Methods of Routine Analysis of Yellow and Orange Pigments Containing Chromium Compounds, Blue Pigments and Chrome Green (D 126 – 35), as proposed by Subcommittee VIII.

IV. Withdrawal of Tentative Revision of Standard.—The committee recommends withdrawal of the tentative revision of the following standard:

Standard Definitions of Terms Relating to Paint Specifications (D 16 – 24), as proposed by Subcommittee VI.

The above recommendations have been submitted to letter ballot of the committee, which consists of 207 members; 84 members have returned their ballots. The analysis of the vote of the committee is given in Table I.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee III on Testing of Paint Vehicles (H. A. Gardner, chairman).—This subcommittee recommends that the Tentative Specifications for Raw Soybean Oil (D 124 – 33 T) be retained for another year in a tentative status, owing to possible revisions that may be necessary, and in view of the active work being conducted on soybean oil by the Farm Chemurgic Council.

This subcommittee contemplates active work in connection with oiticica oil because this material more nearly approaches tung oil in its properties than any other vegetable oil. It is the hope of the committee that this work will ultimately lead to the development of specifications for this material.

Subcommittee VI on Definitions (D. W. Edgerly, chairman).—This subcommittee recommends withdrawal of the tentative revision[1] of the Standard Definitions of Terms Relating to Paint Specifications (D 16 – 24). This tentative revision has stood for many years without sufficient general agreement to permit recommendation for its adoption as standard.

Subcommittee VII on Accelerated Tests for Protective Coatings (H. A. Nelson, chairman).—This subcommittee recommends that the Tentative Specifications for Wood to be Used as Panels in Weather Tests of Paints and Varnishes (D 358 – 35 T) be retained in a tentative status for another year pending further revision.

A report of two series of accelerated weathering tests on varnishes made by Group 3 on Varnish (W. R. Fuller, chairman) is appended hereto.

This subcommittee reports progress in the work of its several groups where cooperative tests are under way that are partially completed or awaiting results of exposure tests before being further reported upon. Additional cooperative work is contemplated for the future.

Subcommittee VIII on Methods of Analysis of Paint Materials (E. F. Hickson, chairman).—This subcommittee is continuing its program of cooperative work on an improved method of test for hiding power, and in consequence recommends that the Tentative Method of Test for Comparative Hiding Power of White Pigments (D 406 – 35 T) and the Tentative Method of Test for Comparative Hiding Power of Paints (D 344 – 32 T) be continued as tentative without revision. In connection with backgrounds for brush-out tests, this subcommittee has given consideration to such matters as design of background, brightness tolerances, effect of varying spreading rates of paints on hiding power results, and availability of various paper test panels on which brush-out tests may be conducted. It is hoped that a new method of test for hiding power of paints, working at incomplete hiding and on a dry film basis, will be developed that will permit revision of the present method during the coming year.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1400 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 1526.

This subcommittee recommends that the following tentative methods of test be submitted to the Society for adoption as standard:

> Method of Test for Tinting Strength of White Pigments or White Pigment Pastes (D 332 – 35 T),[1] and
>
> Methods of Test for Mass Color and Tinting Strength of Dry Color Pigments or Pastes (D 387 – 35 T).[1]

The subcommittee further recommends that the tentative revision[2] proposed in 1935 in the Standard Methods of Routine Analysis of Yellow and Orange Pigments Containing Chromium Compounds, Blue Pigments and Chrome Green (D 126 – 35)[3] be submitted to the Society for adoption as standard. In view of the fact that there is now available a separate method of test for tinting strength, it is also recommended that the following revision in this standard be submitted to the Society for immediate adoption:

Section 3.—Delete the test for tinting strength described in this section and replace it with the following:

> 3. *Tinting Strength.*—Tinting strength shall be determined in accordance with the Tentative Methods of Test for Mass Color and Tinting Strength of Dry Color Pigments or Pastes (A.S.T.M. Designation: D 387 – 35 T) of the American Society for Testing Materials.

The subcommittee likewise recommends that in the Standard Methods of Routine Analysis of Yellow, Orange, Red and Brown Pigments Containing Iron and Manganese (D 50 – 33)[4] the following revision be submitted to the Society for immediate adoption as standard:

Section 3.—Delete the test for tinting strength described in this section and replace it with the following:

> 3. *Tinting Strength.*—Tinting strength shall be determined in accordance with the Tentative Methods of Test for Mass Color and Tinting Strength of Dry Color Pigments or Pastes (A.S.T.M. Designation: D 387 – 35 T) of the American Society for Testing Materials.

The attention of the subcommittee has been drawn to a requirement appearing in Section 2 of the Standard Method of Routine Analysis of Dry Cuprous Oxide (D 283 – 33)[5] that the aluminum test panel shall be

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, pp. 877, 882 (1935); also 1935 Book of A.S.T.M. Tentative Standards, pp. 657, 662.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1399 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 1525.

[3] 1935 Supplement to Book of A.S.T.M. Standards, p. 138.

[4] 1933 Book of A.S.T.M. Standards, Part II, p. 630.

[5] *Ibid.*, p. 553.

"free from iron and copper." In view of the fact that this is not commercially feasible, the subcommittee recommends that the following revision be submitted to the Society for immediate adoption as standard:

Section 2.—Change the fifth sentence to read as follows by the addition of the italicized words and figures and the omission of the words in brackets:

> Place in the solution a piece of clean, pure sheet aluminum [(zinc may also be used) free from iron and copper] *having a minimum purity of 99.80 per cent and to contain a maximum of 0.02 per cent copper.*

The subcommittee recommends that the present tentative revision of the Standard Methods of Routine Analysis of White Linseed Oil Paints (D 215 – 35) be continued as tentative.

Subcommittee IX on Varnish (W. T. Pearce, chairman).—This subcommittee reports progress on the problems being studied by its various groups, as follows:

Group 1 on Methods for Determining Reactivity of Varnish reports that it is trying out two types of tests using green seal zinc oxide in one, and in another, zinc oxide paste ground in alkali refined linseed oil. Several types of varnish vehicles are being examined, noting consistency of the enamel when first made and after storage for a given time.

Group 2 on Development of Standard Adhesion Test reports progress and the intention to keep in close touch with the New York Paint and Varnish Production Club which is carrying out a similar type of work.

Group 3 on Effect of Temperature, Humidity and Other Factors upon the Physical Properties of Varnishes reports progress.

Group 4 on Study of Methods for Evaluating Failure of Varnishes upon Exposure has nearly completed its work and will propose next year a standard method for evaluating failures of clear varnishes.

In addition, the subcommittee is undertaking the development of a method for determining color of varnishes.

Subcommittee XII on Turpentine (F. P. Veitch, chairman).—This subcommittee recommends for immediate adoption the following changes in the Standard Methods of Sampling and Testing Turpentine (D 233 – 33):[1]

Section 2 (a).—Change the first sentence of the second paragraph of this section to read as follows by the addition of the italicized word and figure and the omission of those in brackets:

> The composite sample thus obtained shall be thoroughly mixed and from it three samples of not less than [1 qt.] *1 pt.* each shall be placed in clean, dry, glass bottles or tin cans, which shall be nearly filled with the sample and securely stoppered with new, clean corks or well-fitting covers or caps.

Section 2 (b).—Change from its present form: namely,

> (*b*) ***From Loaded Tank Car or Other Large Vessel.***—The composite sample taken shall be not less than 5 gal. and shall consist of numerous small samples of not more

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 668.

than 1 qt. each taken from the top, bottom, and intermediate points by means of a metal or glass container with removable stopper or top. This device, attached to a suitable pole, is lowered to the various desired depths, when the stopper or top is removed and the container allowed to fill. The sample thus obtained is handled as described in Paragraph (*a*).

to read as follows:

(*b*) *From Loaded Tank Car or Other Large Vessel.*—The composite sample shall be a mixture of three 1-qt. samples, one taken from the top, one from the middle section, and one from the bottom[a] of the car or tank by means of a metal or glass container with removable stopper (see Section 46, Fig. 1 of the Standard Methods of Sampling Petroleum and Petroleum Products (A.S.T.M. Designation: D 270) of the American Society for Testing Materials), or by means of a sampling bomb or thief (see Section 55 (*d*), Fig. 5 of the Standard Methods D 270). The sample thus obtained shall be handled as described in Paragraph (*a*).

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[a] The "bottom" sample shall be taken above the separated water that may be in the bottom of the tank.

Section 6.—Change from its present form: namely,

6. Determine specific gravity at 15.5/15.5 C., by any convenient method that is accurate within 2 points in the fourth figure.

to read as follows:

6. Determine specific gravity at 15.5/15.5 C., by any convenient method that is accurate within 2 points in the fourth figure. Specific gravity determinations may be made at any convenient temperature other than 15.5 C. If done with a hydrometer or other apparatus standardized at 15.5 C., the value thus obtained may be corrected to 15.5/15.5 C. by adding to or subtracting from the observed reading 0.00082 for each degree Centigrade that the temperature of the liquid is respectively above or below 15.5 C. If specific gravity is determined on any basis other than by reference to 15.5 C., the specific gravity at 15.5/15.5 C. shall be calculated by first calculating the density at the temperature of observation, then converting this to density at 15.5 C. by applying the above factor, and finally obtaining the specific gravity by dividing the calculated density by 0.999 (density of water at 15.5 C.).

Subcommittee XIII on Shellac (J. W. Paisley, chairman).—This subcommittee recommends to the Society for publication as tentative the following revision in the Standard Methods of Sampling and Testing Shellac (D 29 - 33):[1]

Section 19.—Delete this section which describes the procedure for the determination of wax in orange, button, seed and regular bleached shellac. This revision is considered desirable, since in many instances the method in question gives varying and low results.

This subcommittee has obtained a series of test results on the Angelo color method. These data as well as the details of the test are to be further studied with a view to determining possible sources of variation in results of different operators, leading to recommendations that would provide more concordant findings.

This subcommittee further reports that none of the present methods for determining water-soluble material in non-volatile shellac varnishes appear suitable, and in view of the fact that no existing standards or tentative standards contain specifications or methods for making such determinations, this problem will be considered for study.

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 678.

Subcommittee XV on Specifications for Pigments, Dry and In Oil When Marketed in That Form (H. E. Smith, chairman).—This subcommittee recommends submission to the Society for adoption as standard of the Tentative Specifications for Titanium Dioxide (D 384 – 34 T).[1]

After consideration of classification and nomenclature of zinc sulfide pigments, this subcommittee proposes the following recommendations: (*a*) the original lithopone, a pigment containing zinc sulfide and barium sulfate in equimolecular ratio, should retain its present name, lithopone, (*b*) the pigment consisting of substantially commercially pure zinc sulfide should retain its present name, zinc sulfide, and (*c*) there remain intermediate pigments containing more zinc sulfide than is equivalent to the equimolecular ratio of zinc sulfide. Specifications have already been issued for one of these, namely, a zinc sulfide-barium sulfate combination, under the title, Tentative Specifications for High Zinc Sulfide Lithopone (D 385 – 34 T).[1] In order to provide an opportunity for extension of the same system to zinc sulfide pigments made with other inert materials, this subcommittee recommends that the name of this pigment be changed to "zinc sulfide pigment (barium)," and with this revision that the Tentative Specifications D 385 – 34 T be submitted to the Society for adoption as standard.

This subcommittee recommends for publication as tentative, the following revision in the Standard Specifications for Lithopone (D 208 – 26):

Section 3 (*b*).—Change the requirement for zinc oxide from its present value of "2.0 per cent max." to read "1.0 per cent max."

This recommendation is made because recent improvements in manufacturing processes by all manufacturers permit this increase in the standard for purity and uniformity, which is desirable.

This subcommittee further recommends that the Tentative Specifications for Zinc Sulfide (D 386 – 34 T)[1] be revised as follows and adopted as standard:

Section 3 (*b*).—Change the requirement for zinc sulfide from its present value of "95.0 per cent min." to read "97.0 per cent min."

It is believed by this subcommittee that commercial conditions now warrant the increase in minimum percentage content of zinc sulfide as recommended above.

This subcommittee reports that certain grades of American process zinc oxide pigment approach those made by the French process more nearly than formerly, and in consequence a group interested in zinc pigments has been asked to study this entire matter with respect to differences and distinction between zinc oxides resulting from the American and French processes.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, pp. 860, 862, 864 (1934); also 1935 Book of A.S.T.M. Tentative Standards, pp. 648, 650, 652.

This subcommittee is making a thorough study of earth colors with reference to preparing specifications for some of them. The study will cover a better method of measure and reference standard for the color and shade of the pigments, and development of ceramic tiles to constitute stable standards for a color and shade for sienna which will be generally acceptable commercially.

Consideration is also being given to the use in pigment specifications of some of the more recent scientific methods for the quantitative measurement and specification of the physical properties in terms of fundamental units.

Subcommittee XVIII on Physical Properties of Materials (F. P. Ingalls, chairman).—This subcommittee, in reporting progress, stressed the fundamental nature of the work under consideration, summarizing its aims and purposes as follows: (1) to write a definition of gloss that will be sufficiently precise to be acceptable to science, and so worded as to be clearly understood and of use commercially, (2) to investigate the relative merits of all instruments and apparatus that are commercially available, upon which satisfactory gloss determinations can be made, and (3) to obtain such information as may, through cooperative effort, lead ultimately to the development of a satisfactory gloss specification and method of test.

This subcommittee reports that the first objective (definition of gloss) seemed fairly simple, because gloss as a descriptive term appeared so generally understood. It soon developed that the committee was dealing with a loosely defined conception, resulting from a group of interdependent and somewhat abstruse phenomena that could not be adequately described by a single word. In consequence, the terms "gloss," "polish," and "image reproducibility" were selected, and definitions covering these are in preparation for submission as tentative during the coming year.

Subcommittee XXV on Cellulose Ester Coatings (R. M. Carter, chairman).—This subcommittee recommends that the following tentative specifications be submitted to the Society for adoption as standard:

Specifications for Amyl Acetate (from Fusel Oil) (85 to 88 per cent Grade) (D 318 - 34 T),[1]
Specifications for Industrial 90 per cent Benzene (Benzol) (D 361 - 33 T),[2]
Specifications for Industrial Pure Toluene (Toluol) (D 362 - 33 T),[2]
Specifications for Industrial Xylene (Xylol) or Solvent Naphtha (D 364 - 33 T),[2] and
Specifications and Tests for Tricresyl Phosphate (D 363 - 33 T).[2]

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, p. 878 (1934); also 1935 Book of A.S.T.M. Tentative Standards, p. 676.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, pp. 731, 732, 736, 733 (1933); also 1935 Book of A.S.T.M. Tentative Standards, pp. 677, 678, 682, 679.

This subcommittee is considering a questionnaire to be prepared covering a future program of work, to include development of a method for determination of evaporation rate of solvents; a method for determination of dilution ratio; investigation of latent solvent power, as of alcohols; a study of tests on finished lacquers; and the development of specifications for additional plasticizers such as dibutyl phthalate and dimethyl phthalate.

The election of officers for the ensuing term of two years resulted in the re-election of the present incumbents.

This report has been submitted to letter ballot of the committee which consists of 207 members; 84 members returned their ballots, of whom 71 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

ALLEN ROGERS,
Chairman.

M. REA PAUL,
Secretary.

REPORT OF SUBCOMMITTEE VII ON ACCELERATED TESTS FOR PROTECTIVE COATINGS

Group 3 on Varnish (W. R. Fuller, chairman) of Subcommittee VII has conducted two series of accelerated weathering tests on varnishes. The first series, completed in 1934, was considered inconclusive because exterior exposure tests were not run in parallel with the machine tests. To overcome this shortcoming a second series of tests, which has just been concluded, included exterior exposures in three localities. A brief review of the first series of tests is given, both for completeness and as a background for consideration of the second series.

REVIEW OF FIRST TEST

Five laboratories participated in the work, using seven different machines. The cooperators were:

1. H. G. Arlt, Bell Telephone Laboratories, Inc.
2. W. R. Fuller, Pratt & Lambert, Inc.
3. R. J. Moore, Bakelite Corp.
4. F. C. Schmutz, Research Division, The New Jersey Zinc Co.
5. G. G. Sward, Institute of Paint and Varnish Research.

The machines employed may be described briefly as follows:

Machine A.—Weather-Ometer, Type H.G., twin Atlas carbon arcs which revolve within 8 in. of panels. Water spray for 7 min. each half hour. Detailed description is given on page 317 of "Physical and Chemical Examination of Paints, Varnishes, Lacquers and Colors," Laboratory Manual, H. A. Gardner, Sixth Edition, October, 1933.

Machine B.—Mercury vapor quartz lamp. Panels mounted on interior of revolving drum and pass under water for 4 min. in each half hour. Detailed description is given on pages 319 and 321 of "Physical and Chemical Examination of Paints, Varnishes, Lacquers and Colors," Laboratory Manual, H. A. Gardner, Sixth Edition, October, 1933.

Machine C.—60-Ampere carbon arc machine, using National Carbon Co. Sunshine carbons. Detailed description is given on page 321 of "Physical and Chemical Examination of Paints, Varnishes, Lacquers and Colors," Laboratory Manual, H. A. Gardner, Sixth Edition, October, 1933.

Machine D.—Atlas Type BW-M Weather-Ometer. Detailed description is given in the literature of the Atlas Electric Devices Co., 361 W. Superior St., Chicago, Ill.

Machine E.—Modified Weather-Ometer, using standard Atlas carbon arc light. The drum of machine E is 30 in. in diameter and 36 in. in height. The racks hold four rows of 3 by 6-in. panels. The light source is a standard Atlas carbon arc, which is placed at the vertical center of the drum. In order to obtain a higher temperature and more severe light exposure under dry conditions, the light is offset from the vertical center so as to be 21.5 in. from the spot at which the panels are wetted, and 8.5 in. from the diametrically opposite side of the drum. The maximum temperature of the panels is approximately 130 F. (55 C.). The drum rotates at the rate of one revolution per hour. Wetting is accomplished by a water spray. The panels are under the direct action of this spray for 2 min. during each revolution and they remain wet for approximately 15 min. The machine is operated constantly 6 days a week. On the seventh day operation is stopped for a period of 8 hr., during which the panels are chilled to −20 F. (−29 C.) for 1 hr., warmed to 140 F. (60 C.) for 1 hr., then exposed to room conditions for 6 hr. Chilling is done by means of dry ice in a small refrigerator. Since there are four rows of panels in the machine, the rows are interchanged weekly to equalize light exposure. The exposure to which the panels are subjected may be summarized as follows:

Length of cycle	168 hr.	
Light and heat, with 1 wetting per hour	160 hr.	95.2 per cent
Refrigeration at —20 F. (—29 C.)	1 hr.	0.6 per cent
Heat at 140 F. (60 C.)	1 hr.	0.6 per cent
Room conditions	6 hr.	3.6 per cent

Machine G.—Machine of special design. Mercury vapor quartz lamp and water spray. Detailed description is given on pages 454 to 459 of "Physical and Chemical Examination of Paints, Varnishes, Lacquers and Colors," Laboratory Manual, H. A. Gardner, Seventh Edition, October, 1935.

Machine H.—Machine of special design. Mercury vapor quartz lamp, water spray and refrigeration. Detailed description is given on pages 327 to 336 of "Physical and Chemical Examination of Paints, Varnishes, Lacquers and Colors," Laboratory Manual, H. A. Gardner, Sixth Edition, October, 1933.

The cycles of the various machines included in the first test series were as follows:

MACHINE A

Continuous light from 2 arcs which revolve within 8 in. of the panels and give maximum panel temperature of 140 F. (60 C.). Water spray from a revolving nozzle for 7 min. each half hour (with light on).

MACHINE B

Daily Cycle:

23 hr. per day. Continuous light. Panels immersed under water 4 min. each half hour.

1 hr. per day. Room exposure.

MACHINE C

Daily Cycle:

5 p.m. to 3 a.m. (10 hr.).	Light only.
3 a.m. to 10 a.m. (7 hr.).	Room exposure.
10 a.m. to 5 p.m. (7 hr.).	Water spray only.

MACHINE D

Six days a week:

8 a.m. to 10 a.m. (2 hr.).	Water spray only, no light.
10 a.m. to 3 p.m. (5 hr.).	Light only. Panel temperature, approximately 112 F. (45 C.).
3 p.m. to 5 p.m. (2 hr.).	Water spray only.
5 p.m. to 8 a.m. (15 hr.).	Light only. Panel temperature, approximately 112 F. (45 C.).

Seventh day:

8 a.m. to 10 a.m. (2 hr.).	Water spray only.
10 a.m. to 8 a.m. (22 hr.).	Light only. Panel temperature, approximately 112 F. (45 C.).

Summary:

	HOURS PER WEEK	PERCENTAGE OF TOTAL
Light only	146	86.9
Water only	22	13.1

MACHINE E

Six days a week:

Machine operated constantly on hourly cycle comprising light only for 58 min. and water spray (with light on) for 2 min. Panels remain wet for 15 min. Maximum temperature of panels, 130 F. (55 C.).

Seventh day:

16 hr.	Same as other days.
1 hr.	Refrigeration at —20 F. (—29 C.) with dry ice.
1 hr.	140 F. (60 C.) in oven.
6 hr.	Room exposure and observation.

MACHINE G

Monday	9 hr. 15 hr.	Moisture[a] Light, high humidity[b]
Tuesday	2½ hr. 3 hr. 3½ hr. 15 hr.	Water spray[c] Light, low humidity[d] Moisture[a] Light, high humidity[b]
Wednesday	2½ hr. 6½ hr. 15 hr.	Observation Moisture[a] Light, high humidity[b]
Thursday	Repeat Monday	
Friday	Repeat Tuesday	
Saturday	2½ hr. 21½ hr.	Observation Moisture[a]
Sunday	24 hr.	Moisture[a]
Summary	75 hr. (44.6 per cent) 6 hr. (3.6 per cent) 5 hr. (3.0 per cent) 77 hr. (45.8 per cent) 5 hr. (3.0 per cent)	Light, high humidity[b] Light, low humidity[d] Water spray[c] Moisture[a] Observation

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[a] Moisture: 90 per cent relative humidity, 100 F. (38 C.).
[b] Light, high humidity: 85 per cent relative humidity, panel temperature approximately 155 F. (68 C.).
[c] Water spray: water at 100 F. (38 C.).
[d] Light, low humidity: 10 per cent relative humidity, panel temperature approximately 170 F. (77 C.).

MACHINE H

Monday	2½ hr.		Refrigeration
	3½ hr.		Water spray
	15½ hr.		Light, high humidity
	2½ hr.		Light, low humidity
Tuesday	3½ hr.		Water spray
	2½ hr.		Refrigeration
	15½ hr.		Light, high humidity
	2½ hr.		Light, low humidity
Wednesday	2½ hr.		Refrigeration
	3½ hr.		Water spray
	18 hr.		Light, high humidity
Thursday	2½ hr.		Refrigeration
	3½ hr.		Water spray
	15½ hr.		Light, low humidity
	2½ hr.		Light, high humidity
Friday	2½ hr.		Refrigeration
	3½ hr.		Water spray
	18 hr.		Light, low humidity
Saturday	Repeat Wednesday		
Sunday	22 hr.		Light, high humidity
	2 hr.		Light, low humidity
Summary	91½ hr.	(54.4 per cent)	Light, high humidity
	40½ hr.	(24.1 per cent)	Light, low humidity
	21 hr.	(12.5 per cent)	Water spray
	15 hr.	(9.0 per cent)	Refrigeration

Table I gives an analysis of the cycles employed. In arriving at the percentage figures for the various exposure conditions, inspection periods and periods of normal room exposure were omitted. Water exposure may be either by spray or immersion, depending on the machine.

The six varnishes used were exactly the same as in the second test series and the panels were prepared in substantially the same manner, hence these details are omitted. For the same reason, the methods of making observations and reporting results are not included.

For simplicity, only the integrity or durability results over black primer are considered. The basis for judging the machine results was the exterior durability rating of the varnishes as reported by the supplier. The exterior exposures in the subsequent series altered this order only to the very slight extent that two varnishes that rated consecutively and were approximately equal in durability were reversed. These varnishes fell in the middle range of durability.

The results are shown in Table II, in which the exterior exposure ratings are those determined by actual exposures in the subsequent series. Machine A caused failure of four varnishes at almost the same time and the one varnish that had not failed when the test was concluded is second poorest. The failures developed suddenly after exposure for 14 to 16 days. The form of failure had little resemblance to exterior failure and appeared to be burning due to the closeness of the carbon arc to the panels.

Machine B rated the most durable varnish (which differs in type from the others) last. Otherwise, the order was correct except for failure to distinguish between two varnishes of consecutive durability. Failures developed in 7 to 17 days and were fairly typical.

Machine C produced checking in only one varnish after 28 days, the others showing only dulling or blistering.

Machine D ranked the most durable varnish next to last. Otherwise, the order was correct except for reversal of two consecutive varnishes. Failures were fairly typical and required 20 to 42 days.

TABLE I.—ANALYSIS OF CYCLES, FIRST TEST SERIES.

	Machine A	Machine B	Machine C	Machine D	Machine E	Machine G	Machine H
Name of Machine........	Weather-Ometer, Type HG	Uviarc	60-Amp. Carbon Arc	Atlas Weather-Ometer, Type BW-M	Modified Weather-Ometer	Special Design, Multiple Unit	Special Design, Combination Unit
Light Source.............	Enclosed, twin, revolving 13-amp. carbon arcs.	Mercury-quartz 20-in. tube, low pressure.	Open 60-amp. carbon arc.	Enclosed carbon arc, 13 amp.	Enclosed carbon arc, 13 amp.	Mercury-quartz 20-in. tube, low pressure.	Mercury-quartz 20-in. tube, low pressure.
Distance of panels from light, in.............	8	18	24	15	$8\frac{1}{2}$ to $21\frac{1}{2}$	24	24
Approximate temperature of panels, max...	140 F. (60 C.)	150 F. (65 C.)	158 to 167 F. (70 to 75 C.)	112 F. (45 C.)	130 F. (55 C.)	170 F. (77 C.)	140 F. (60 C.)
Number of changes per week...............	322	322	14	22	322	17	23
Light, no water, per cent	76.6	86.6	58.8	86.9	95.5	......	......
Light and water, per cent	23.4	13.4	......	......	3.3	......	......
Water, no light, per cent..	......	......	41.2	13.1	......	3.1	12.5
Light, high humidity, per cent.............	......	......	......	......	......	46.0	54.4
Light, low humidity, per cent................	......	......	......	......	......	3.7	24.1
High humidity, no light, per cent.............	......	......	......	......	......	47.2	......
Refrigeration, per cent....	......	......	......	......	0.6	......	9.0
Heat, per cent...........	......	......	......	......	0.6	......	......

Machine E gave rather poor correlation with exterior results. It failed to make any distinction between the two varnishes in one group and between the three varnishes in another group. Failures occurred between 14 and 28 days.

Machine G failed to produce typical failures and was extremely slow, at least three panels showing no definite failure after 72 days. The test was duplicated in machine G with the cycle modified by placing Corex D filters over the panels. This cycle gave the most typical failures of any in the test and failures occurred in 9 to 16 days. There was fair agreement with exterior exposure rating.

Machine H, which was designed primarily for paint testing, caused no checking failures, only dulling and finally rusting. Results were extremely slow and afforded no basis for durability rating.

On the whole, machines B and D and machine G with Corex D filters gave promising results, while the other cycles were of little value.

TABLE II.—INTEGRITY RATINGS OVER BLACK PRIMER, FIRST TEST SERIES.

NOTE.—The numbers indicate the rating, the number 1 indicating highest rating and 6 the lowest rating. Brackets indicate that two or more varnishes had the same rating.

Varnish	Exterior Exposure	Machine A	Machine B	Machine C	Machine D	Machine E	Machine G	Machine H
I	5	1	4	5	4	3 4 5	3 4	3 4
II	6	6	5	6	6	6	5	5
III	3	4 5	3	1 2 3 4	3	3 4 5	3 4	3 4
IV	2	3	1	3	1	1 2	1	1
V	4	2	2	1 2 3 4	2	1 2	2	2
VI	1	4 5	6	1 2 3 4	5	3 4 5	6	6

OUTLINE OF SECOND TEST

In view of unsatisfactory results, machines A, C and H were omitted from the second test and machine B was also withdrawn. Machine E was included in the second test, notwithstanding poor results in the first. Mr. O. J. Shobe consented to participate in the second series, giving four machines. In addition, exterior exposures were conducted at Miami, Fla., by C. Hubbard Davis, Sub-Tropical Testing Service, and at Buffalo, N. Y., and New York City.

Following is a list of those who cooperated in the second test series:

1. H. G. Arlt, Bell Telephone Laboratories, Inc.
   Machine and exterior exposures.
2. C. Hubbard Davis, Sub-Tropical Testing Service.
   Exterior exposure.
3. W. R. Fuller, Pratt & Lambert, Inc.
   Machine and exterior exposures.
4. R. J. Moore, Bakelite Corp.
   Machine exposure.

5. O. J. Shobe, The Glidden Co.
   Machine exposure.
6. C. C. Hartman, National Bureau of Standards.
   Photochemical embrittlement test.

The seven sets of panels in the weathering tests were exposed as shown below. Machines are designated by the same letters as in the first test series.

Exterior Exposures:

New York City, 45 deg., facing south.
Miami, Fla., 45 deg., facing south.
Buffalo, N. Y., 45 deg., facing south.

Machine Exposures:

Machine D.—Atlas Type BW-M Weather-Ometer.

Machine E.—Modified Weather-Ometer, using standard Atlas carbon-arc light.

Machine F.—Machine of special design. The drum of machine F is 42 in. in diameter and 30 in. in height. Test panels are 3 by 8 in. The light source is twin Sunshine carbons, made by National Carbon Co., constant current, 60 amp. at 50 v. across arc, motor driven electrode feed. No. 22 copper-coated Sunshine carbons in upper holder and No. 13 copper-coated Sunshine carbons in lower holders. Arcs enclosed by Corex D filter panels with air drawn through for cooling and taking off fumes. Panels are 18 in. from light and the maximum temperature of the panels is approximately 130 F. (55 C.). The drum rotates at the rate of one revolution in 2 hr. Wetting is accomplished by a water spray, which covers about 4 in. along the circumference of the drum. The exposure cycle may be summarized as follows:

Length of cycle	2 hr.	
Light	1 hr. 56 min.	97 per cent
Light and water		3 per cent

Machine G.—Machine of special design. Mercury vapor quartz lamp and water spray. Corex D filters attached to panels.

The cycles of the various machines included in the second test series were as follows:

MACHINE D

Six days a week:

8 a.m. to 10 a.m.	(2 hr.).	Water spray only, no light.
10 a.m. to 3 p.m.	(5 hr.).	Light only. Panel temperature, approximately 112 F. (45 C.).
3 p.m. to 5 p.m.	(2 hr.).	Water spray only.
5 p.m. to 8 a.m.	(15 hr.).	Light only. Panel temperature, approximately 112 F. (45 C.).

Seventh day:

8 a.m. to 10 a.m. (2 hr.). Water spray only.
10 a.m. to 8 a.m. (22 hr.). Light only. Panel temperature, approximately 112 F. (45 C.).

Summary:	HOURS PER WEEK	PERCENTAGE OF TOTAL
Light only	146	86.9
Water only	22	13.1

MACHINE E

Six days a week:

Machine operated constantly on hourly cycle comprising light only for 58 min. and water spray (with light on) for 2 min. Panels remain wet for 15 min. Maximum temperature of panels, 130 F. (55 C.).

Seventh day:

16 hr. Same as other days.
1 hr. Refrigeration at −20 F. (−29 C.) with dry ice.
1 hr. 140 F. (60 C.) in oven.
6 hr. Room exposure and observation.

MACHINE F

Continuous light. Panels sprayed with water for about 3½ min. every 2 hr.

MACHINE G

Monday	9 hr.	Moisture[a]
	15 hr.	Light, high humidity[b]
Tuesday	2½ hr.	Water spray[c]
	3 hr.	Light, low humidity[d]
	3½ hr.	Moisture[a]
	15 hr.	Light, high humidity[b]
Wednesday	2½ hr.	Observation
	6½ hr.	Moisture[a]
	15 hr.	Light, high humidity[b]
Thursday	Repeat Monday	
Friday	Repeat Tuesday	
Saturday	2½ hr.	Observation
	21½ hr.	Moisture[a]
Sunday	24 hr.	Moisture[a]
Summary	75 hr. (44.6 per cent)	Light, high humidity[b]
	6 hr. (3.6 per cent)	Light, low humidity[d]
	5 hr. (3.0 per cent)	Water spray[c]
	77 hr. (45.8 per cent)	Moisture[a]
	5 hr. (3.0 per cent)	Observation

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[a] Moisture: 90 per cent relative humidity, 100 F. (38 C.).

[b] Light, high humidity: 85 per cent relative humidity, panel temperature approximately 155 F. (68 C.).

[c] Water spray: Water at 100 F. (38 C.).

[d] Light, low humidity: 10 per cent relative humidity, panel temperature approximately 170 F. (77 C.).

Table III gives an analysis of the cycles employed. In arriving at the percentage figures for the various exposure conditions, inspection periods and periods of normal room exposure were omitted.

Varnishes:

The six varnishes tested were exactly the same as the varnishes in the previous series. No description of these varnishes will be given, since the basis of rating their exterior performance will be entirely the results of the exterior exposure tests.

Panels and Preparation:

The varnishes were applied on steel panels over pigmented varnish primer. Tests were run in duplicate, one series being over a black primer, the other series over a white primer. In addition, two of the varnishes were applied over a white alkyd resin primer and the same two varnishes were applied over a black phenolic resin varnish primer.

The details of the preparation of the panels are as follows:

Smooth automobile steel was used as base material for test panels.

TABLE III.—ANALYSIS OF CYCLES, SECOND TEST SERIES.

	Machine D	Machine E	Machine F	Machine G
Name of Machine	Atlas Weather-Ometer, Type BW-M	Modified Weather-Ometer	Special Design	Special Design, Multiple Unit
Light Source	Enclosed carbon arc, 13 amp.	Enclosed carbon arc, 13 amp.	Twin arcs, copper-coated Sunshine carbons, 60 amp. Corex D filter.	Mercury-quartz 20-in. tube, low pressure. Corex D filter.
Distance of panels from light, in.	15	$8\frac{1}{2}$ to $21\frac{1}{2}$	18	24
Approximate temperature of panels, max	112 F. (45 C.)	130 F. (55 C.)	130 F. (55 C.)	170 F. (77 C.)
Number of changes per week	22	322	84	17
Light, no water, per cent	86.9	95.5	97	......
Light and water, per cent	......	3.3	3	......
Water, no light, per cent	13.1	......	......	3.1
Light, high humidity, per cent	......	......	......	46.0
Light, low humidity, per cent	......	......	......	3.7
High humidity, no light, per cent	......	......	......	47.2
Refrigeration, per cent	......	0.6	......	......
Heat, per cent	......	0.6	......	......

Exterior panels 3 by 12 in. were made by dividing 6 by 12-in. panels into two sections.

Machine panels of size required for various machines, varying from $2\frac{1}{2}$ by $5\frac{1}{2}$ in. to 3 by 12 in.

Backs of panels were given one spray coat of red primer (Navy Department Specification No. P–23a), numbered, and given one brush coat of Spar Varnish (Navy Department Specification No. V–10c).

Tests were run in duplicate, one series with panels primed on the face with one spray coat of black eggshell varnish primer, other series with panels primed with one spray coat of white eggshell varnish primer. In addition, varnishes IV and VI were applied over a black phenolic varnish primer and over a white alkyd varnish primer. These primers were designated as B_1, W_1, B_2 and W_2, respectively.

Priming coats were allowed to air dry 3 days; two brush coats of varnish were then applied, allowing 2 days between coats and 7 days after the last coat before exposing or packing the panels for shipment.

Each cooperator was also supplied with a set of panels on tin finished in the same manner as the test panels for use as standards in rating gloss and color change.

Method of Making Observations and Reporting Results:

The records of the test were kept on the form recommended by the Exposure Test Committee of the Federation of Paint and Varnish Production Clubs, copy of which is shown in Fig. 1. Failure ratings were made in accordance with the official code of the Federation of Paint and Varnish Production Clubs. Photographs adopted by the New York Paint and Varnish Production Club were supplied to each cooperator for guidance in determining the degree of the various failures. Observations were made on the following:

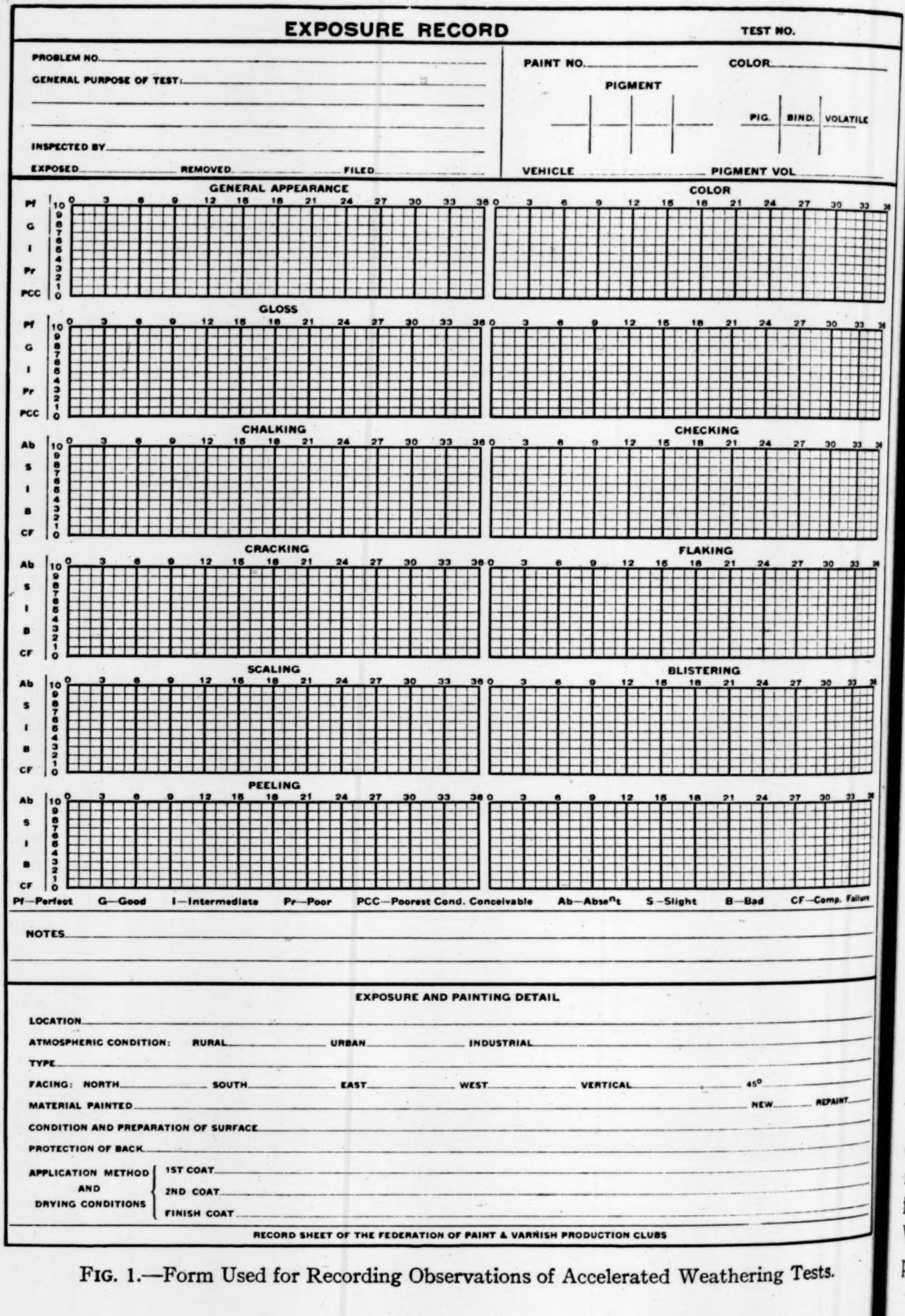
(*a*) Checking
(*b*) Cracking
(*c*) Blistering
(*d*) Scaling
(*e*) Rusting
(*f*) Erosion
(*g*) Gloss
(*h*) Color Change

For the purpose of final rating of the panels items (*a*) to (*f*) were classified under film integrity and items (*g*) and (*h*) under appearance.

Probably the most difficult part of conducting cooperative weathering tests is to determine how to correlate and interpret the final results. The two methods that present themselves are the graphic method and the tabular method. In the former a separate chart is used for each machine or exposure and a separate curve is drawn to represent the record of each varnish. In making such graphs it is necessary to follow a number of arbitrary rules and there may be considerable doubt as to whether the graphs give a true picture of the relative durability of the various varnishes. Aside from this, the graphs are so complicated that it is fully as difficult to interpret them as the original data. While the tabular method also involves arbitrary rules to a lesser extent, it presents the data in a much more convenient and understandable manner. It shows directly the order of durability rating of the various varnishes, which is the objective. Accordingly, the latter method has been adopted for the purpose of this report.

Following are some of the rules that were used in arriving at the integrity ratings:

1. When any panel showed intermediate or greater failure in any integrity property it was considered to have failed.



EXPOSURE RECORD TEST NO.

PROBLEM NO. ____

GENERAL PURPOSE OF TEST: ____

INSPECTED BY ____

EXPOSED ____ REMOVED ____ FILED ____

PAINT NO. ____ COLOR ____

PIGMENT

PIG. | BIND. | VOLATILE

VEHICLE ____ PIGMENT VOL. ____

GENERAL APPEARANCE
COLOR
GLOSS
CHALKING
CHECKING
CRACKING
FLAKING
SCALING
BLISTERING
PEELING
0 3 6 9 12 15 18 21 24 27 30 33 36
10 9 8 7 6 5 4 3 2 1 0
Pf
G
I
Pr
PCC
Ab
S
I
B
CF

Pf—Perfect G—Good I—Intermediate Pr—Poor PCC—Poorest Cond. Conceivable Ab—Absent S—Slight B—Bad CF—Comp. Failure

NOTES ____

EXPOSURE AND PAINTING DETAIL

LOCATION ____

ATMOSPHERIC CONDITION: RURAL ____ URBAN ____ INDUSTRIAL ____

TYPE ____

FACING: NORTH ____ SOUTH ____ EAST ____ WEST ____ VERTICAL ____ 45° ____

MATERIAL PAINTED ____ NEW ____ REPAINT ____

CONDITION AND PREPARATION OF SURFACE ____

PROTECTION OF BACK ____

APPLICATION METHOD AND DRYING CONDITIONS
- 1ST COAT ____
- 2ND COAT ____
- FINISH COAT ____

RECORD SHEET OF THE FEDERATION OF PAINT & VARNISH PRODUCTION CLUBS

FIG. 1.—Form Used for Recording Observations of Accelerated Weathering Tests.

2. Scaling was considered more serious than other forms of failure.
3. If two varnishes showed intermediate failure at the same time but one of these varnishes showed the earlier failure in a second property, the second varnish was given a lower rating.
4. If two varnishes developed intermediate failure at the same time but one of these varnishes showed initial failure earlier, the second varnish was given a lower rating.

Data and Discussion:

The integrity results of the machine tests and exterior exposure tests are given in Table IV. This table was prepared from the original records of the cooperators, supplemented by a review of the test panels and the records by the members of Group 3.

TABLE IV.—INTEGRITY RATINGS, SECOND TEST SERIES.

NOTE.—The numbers indicate the rating, the number 1 indicating highest rating and 8 the lowest rating. A sequence of numbers, such as 1–3, indicates that two or more varnishes have the same rating.

Over Black Primer									Over White Primer								
Varnish	Primer	Exterior Exposure			Machine D	Machine E	Machine F	Machine G	Varnish	Primer	Exterior Exposure			Machine D	Machine E	Machine F	Machine G
		Florida	New York City	Buffalo							Florida	New York City	Buffalo				
I	B_1	7	7	7	7	2–7	5	7	I	W_1	7	7	7	7	6	7	5
II	B_1	8	8	8	8	2–7	8	8	II	W_1	8	8	8	8	7	8	7
III	B_1	5	5	4	4	8	7	6	III	W_1	5	6	4–6	6	8	4	8
IV	B_1	3	4	1–3	5–6	2–7	2	3	IV	W_1	2	3	1–3	3	3	1	1–2
V	B_1	6	6	5	5–6	2–7	3	4	V	W_1	4	5	4–6	4–5	4–5	5	4
VI	B_1	2	3	1–3	1–2	2–7	6	5	VI	W_1	6	4	4–6	4–5	2	6	6
IV	B_2	1	1–2	1–3	3	1	1	2	IV	W_2	1	1–2	1–3	2	4–5	2	1–2
VI	B_2	4	1–2	6	1–2	2–7	4	1	VI	W_2	3	1–2	1–3	1	1	3	3

The three exterior exposures are not in complete agreement. They are in accord as to the ranking of the two poorest varnishes in the test but there is only fair agreement in the ranking of the other varnishes, the results confirming the common observation that locality of exposure influences the relative durability of varnishes. The rating over standard white primer W_1 differs somewhat from the rating over standard black primer B_1, apparently due mainly to the fact that the white primer afforded poorer adhesion and hence tended to reduce the durability of varnishes characterized by poor adhesion to varnish base undercoats.

The substitution of black primer B_2 for black primer B_1 increased the durability of varnish IV and decreased the durability of varnish VI, which reversed their order of durability. The substitution of white primer W_2 for white primer W_1 improved the durability of both varnish IV and varnish VI, the latter to a greater degree. Thus we have additional evidence supporting the general beliefs that (*1*) the undercoats influence the durability of a varnish, and (*2*) the best type of undercoat for one varnish may not be the best for another.

In order to facilitate evaluation of the machines the data of Table IV have been condensed and rearranged in Table V. The exterior durability ratings assigned are based on averaging the results in Florida, New York City and Buffalo. If desired, the machine ratings in this table may be compared with the ratings from the separate exterior exposures by reference to Table IV.

Referring to Table V, it is apparent that Machine D gave good but not perfect agreement with exterior results. Over black primer B_1 varnishes III and IV were reversed, otherwise the rating was correct. Over black primer B_2 the two varnishes tested were reversed in order. Over white primer W_1 the results were consistent with the exterior ratings in so far as the latter can be determined from the incomplete results of the exterior exposures.

TABLE V.—INTEGRITY RATINGS, SECOND TEST SERIES.

NOTE.—Brackets indicate that varnishes bracketed rated the same.

Over Black Primer							Over White Primer						
Primer	Rating	Exterior Exposure	Machine D	Machine E	Machine F	Machine G	Primer	Rating	Exterior Exposure	Machine D	Machine E	Machine F	Machine G
B_1	1	VI	VI	I	IV	IV	W_1	1	IV	IV	VI	IV	IV
B_1	2	IV	III	II	V	V	W_1	2	III	V	IV	III	V
B_1	3	III	IV	IV	I	VI	W_1	3	V	VI	V	V	I
B_1	4	V	V	V	VI	III	W_1	4	VI	III	I	VI	VI
B_1	5	I	I	VI	III	I	W_1	5	I	I	II	I	II
B_1	6	II	II	III	II	II	W_1	6	II	II	III	II	III
B_2	1	IV	VI	IV	IV	VI	W_2	1	?	VI	VI	IV	IV
B_2	2	VI	IV	VI	VI	IV	W_2	2		IV	IV	VI	VI

Machine E gave very poor results, as in the first test. Over black primer B_1 it rated varnish III as poorest, while this varnish is third best. The remaining five varnishes were all rated the same, although they represent an enormous range in durability from best to poorest. Failures were quite rapid, the first intermediate failure occurring in 12 days and all panels showing intermediate failure after 21 days. Failures were not typical, being primarily by extremely fine checking that produced the appearance of dulling and chalking. At the end of the test the varnishes still afforded protection, although the dull appearance would condemn the finishes in actual service.

Machine F gave poor results. While it correctly placed the poorest varnish, it rated the best varnish fourth from the top, placed the second poorest varnish third from the top and misplaced the remaining varnishes. Over white primer W_1 the order was correct in so far as known. Failures were not typical and were much worse on the lower halves of the panels. The panels bear little resemblance to the exterior exposure panels.

Machine G gave fair results. Over black primer B_1 the two poorest varnishes were ranked correctly but the remaining varnishes were all more or less out of order, especially varnish VI which was shifted from first place to third. Over black primer B_2 the correct order was reversed. Over white primer W_1 varnish III was placed at least three positions too low, at the bottom of the table, and varnish I was placed too high. Failures were quite typical but extremely rapid, one varnish showing slight failure after 3 days and all failing after 15 days. This suggests that if the cycle were slowed down, greater accuracy would result. Some of the varnishes developed whitening, which is not typical. This may be related to the fact that the two varnishes which were placed too low are relatively weak in waterproofness. Consideration should be given to reducing the severity of the water exposure in this cycle.

TABLE VI.—APPEARANCE RATINGS, SECOND TEST SERIES.

NOTE.—The numbers indicate the rating, the number 1 indicating highest rating and 8 the lowest rating. A sequence of numbers, such as 6-7-8, indicates that two or more varnishes have the same rating.

Gloss, Over Black Primer										Color Change, Over White Primer									
Varnish	Primer	Exterior Exposure				Machine D	Machine E	Machine F	Machine G	Varnish	Primer	Exterior Exposure				Machine D	Machine E	Machine F	Machine G
		Florida	New York City	Buffalo	Average							Florida	New York City	Buffalo	Average				
I	B_1	8	4	7	7	7	6	6	6	I	W_1	2-3	4	4	4	4	4-5	3-4-5	3-4-5
II	B_1	7	8	8	8	8	3-4	8	8	II	W_1	8	5	5	5	6	4-5	3-4-5	3-4-5
III	B_1	6	6	6	6	5	8	7	7	III	W_1	2-3	3	3	2	2-3	2	3-4-5	3-4-5
IV	B_1	2	7	3-4	4	4	3-4	1-2	2	IV	W_1	5	6-7-8	7-8	7-8	7	7-8	7-8	7-8
V	B_1	5	5	5	5	2	1	3	3-4	V	W_1	7	6-7-8	6	7-8	5	6	6	6
VI	B_1	3-4	1	1	1	6	7	4-5	3-4	VI	W_1	6	2	2	3	2-3	3	2	2
IV	B_2	1	3	3-4	3	3	2	1-2	5	IV	W_2	4	6-7-8	7-8	6	8	7-8	7-8	7-8
VI	B_2	3-4	2	2	2	1	5	4-5	1	VI	W_2	1	1	1	1	1	1	1	1

To recapitulate, one machine gave good but not perfect results, one machine gave fair results and two machines gave poor results. Recalling that four machines were omitted from the second series of tests because they gave poor results in the first series, it seems that great caution must be exercised in accepting the results of accelerated weathering tests of clear varnishes and that the investigator should first satisfy himself as to the reliability and limitations of the particular machine.

While appearance results are of secondary interest, they merit some attention and are recorded in Table VI, which follows the general plan of Table II. In preparing this table the gloss records were taken from the black panels only and the color change records from the white panels only.

Extra columns were inserted for averages of the exterior results on gloss and color change.

It will be noted that there are differences between the three exterior exposures in the rankings for both gloss and color change, and in some cases these differences are substantial. The machines showed even greater variation in results.

Machine D gave fairly accurate results for both gloss and color change. Machine E gave poor accuracy for gloss and good for color change. Machine F was poor for both gloss and color change. Machine G was fair to good for both gloss and color change. The machines as a group definitely underrated the gloss retention of varnish VI.

On the whole, it appears that the accelerated weathering cycles now in use do not afford a very satisfactory test of the gloss retention and color retention properties of clear varnishes.

A number of points are deserving of further comment. One is the rate of failure in the various exposures. The Florida panels failed in approximately one-half the time of the exterior exposures in the northeastern United States. Since, however, the varnish system that was most durable in Florida showed no failure after 14 months and other durable systems required 10 months, Florida exposure does not give the degree of acceleration that is desirable with the durable, modern varnishes. The machines produced much more rapid failures, machine D, which gave best results, causing failure of all but two panels (both coated with the same varnish) in a period of 63 days.

Apparently, if the acceleration of a machine is too great, there is loss of accuracy. It also appears from the results with one machine in this second series and at least one machine in the first series that too high temperatures may cause burning of the finish and lead to results of very doubtful value.

The results do not warrant definite conclusions regarding the relative value of the three types of light source that were employed. It is plain, however, that the choice of a light source having a spectral distribution curve close to that of sunlight is only one of many factors that govern the results of accelerated weathering tests. It may also be noted that in no case did a machine utilizing the type of light that generates the most heat give even fair results. Neither of the two cycles that gave best results comprised refrigeration. Some of those who cooperated have tried cycles with and without refrigeration and have concluded that refrigeration serves no purpose in testing varnishes on metal panels.

At times it has been stated that a large number of cycle changes are desirable. This is not substantiated by this test, since the two machines that gave best results had the smallest number of cycle changes.

The accelerated results on appearance were so poor as to eliminate the machine for this purpose and the integrity results over the black and white primers do not warrant the use of two primers. It is believed that a black primer is best for this type of testing.

Kauri Reduction and Photochemical Embrittlement Tests:

Since accelerated weather testing is a time-consuming, expensive procedure, it seems logical to compare the results with those obtained by simpler, shorter methods. Accordingly, Kauri reduction values of the varnishes were determined and they were subjected to a photochemical embrittlement test by Mr. C. C. Hartman of the National Bureau of Standards. The photochemical embrittlement test panels were prepared by applying two brush coats of varnish to 3 by 5-in. bright tinplate. Each coat was allowed to dry 2 days. Panels were exposed to light only in the Walker-Hickson accelerated weathering machine as described in the National Bureau of Standards *Journal of Research.*[1] The light source in this machine is the Atlas enclosed carbon arc, 220 v. d.c., 13 amp. Panels are 15 in. from center of light source and range in temperature from 197 to 250 F. (90 to 120 C.). After exposure, panels were bent over a $\frac{1}{8}$-in. rod, one set being first brought to 75 F. (24 C.) and another set being placed for 1 hr. on a cake of ice in an ice-box (film side up). Tests were made after exposure to light for 1, 6, 18, 24, 48 and 72 hr. The resistance of the finish to cracking under the conditions of the test is taken as a measure of its durability.

Table VII.—Comparison of Durability, Kauri Reduction and Photochemical Embrittlement Ratings.

Note.—The numbers indicate the rating, the number 1 indicating the highest rating and 6 the lowest rating. A sequence of numbers, such as 1–2, indicates that two varnishes rated the same.

Varnish	Durability Rating	Kauri Reduction		Photochemical Embrittlement Rating
		Value	Rating	
I	5	50	5	5
II	6	20	6	6
III	3	115	4	3
IV	2	140	3	1–2
V	4	145	2	1–2
VI	1	...	?	4

The results of the Kauri reduction and photochemical embrittlement tests are given in Table VII. The durability rankings used in this table are based on exterior exposure over black primer B_1. Varnish VI could not be rated by the Kauri reduction test, since the method is inapplicable to this type of varnish. It will be noted that the other varnishes were rated almost as accurately by the Kauri reduction test as by the best machine. The photochemical embrittlement test was discontinued after 72 hr., at which time there was no cracking of either varnish IV or varnish V. Had the test been continued longer, it is quite possible that varnish IV would have been given the higher rating, thus affording perfect agreement with exterior exposure, with the exception of varnish VI. This test appears quite satisfactory for comparing the more conventional varnishes represented by varnishes I to V, inclusive, but unsuitable for comparing varnishes of the No. VI type with the conventional type. On the whole, it appears that the photochemical embrittlement test is as dependable as any complete weathering cycle now available and that the Kauri reduction test when applicable is only slightly less reliable.

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[1] P. H. Walker and E. F. Hickson, "Accelerated Tests of Organic Protective Coatings," National Bureau of Standards *Journal of Research,* Vol. 1, July, 1928, Research Paper 1.

CONCLUSIONS

Exterior exposures in three different locations did not show complete agreement, which illustrates the well-known influence of climate on exposure results. The primers used under the varnishes influenced the results and in some cases affected the order in both the exterior and accelerated tests. One machine with a specific cycle gave good average results for integrity rating; one other proved to be fair. None of them afforded very satisfactory test for gloss and color retention of clear varnishes. The indications are that accuracy is lost if acceleration is too great. In general, it seems reasonable to conclude that accelerated weathering cycles now in use may offer little, if any, advantage over some shortcut methods, such as the photochemical embrittlement and Kauri reduction tests for testing clear varnishes. Caution should be exercised in accepting the results of the accelerated weathering tests of clear varnishes and the investigator should first satisfy himself as to reliability and limitations of the particular machine and cycle that is to be considered. A more reliable weathering cycle for varnishes would prove distinctly advantageous and members of Group 3 will continue individual work to this end.

Respectfully submitted on behalf of the subcommittee,

H. A. NELSON,
Chairman.

APPENDIX

REPORT OF SPECIAL COMMITTEE ON REORGANIZATION OF COMMITTEE D-1

The purpose of this special committee was to investigate the present structure of Committee D-1, with the view to achieving a closer contact between the Advisory Committee and the various subcommittees of the standing committee. It was also the purpose of this special committee to define the scope of activities and to propose a name for the standing committee that would be more descriptive than its present title.

After considerable study, this Committee on Reorganization, with the approval of the Advisory Committee, proposes the following recommendations for adoption by Committee D-1:

1. *Definition of Scope:*

The scope of Committee D-1 comprises paint, varnish, lacquer, and related products, and materials used in the manufacture thereof.

2. *Change of Name:*

It is proposed that Committee D-1 on Preservative Coatings for Structural Materials be changed in name to "Committee D-1 on Paint, Varnish, Lacquer, and Related Products."

3. *Subcommittee Contacts:*

(*a*) It is proposed that the chairmen of all subcommittees and advisers (as defined in recommendation 4) be requestea to attend such meetings of the Advisory Committee as the chairman of that committee shall designate, in order that they may report on scope of activities and plans for the future. This would tend to achieve a closer tie-up between the Advisory Committee and the other subcommittees of Committee D-1.

(*b*) It is further proposed that one or more subcommittees be assigned to certain members of the Advisory Committee for study, with particular attention to those groups that might be termed inactive. An investigation of the subcommittees' activities and plans, by some member of the Advisory Committee, would insure a fairly complete knowledge by the latter group of everything that is contemplated within the standing committee. If, upon investigation of an inactive subcommittee, it is deemed desirable to recommend that it be disbanded, the plan under item 4 below is proposed as a means of safeguarding all existing standards and the interests of the individuals responsible for their development.

4. ***Advisers:***

It is proposed that, on discharge of any subcommittee responsible for the development of existing standards, one member having an active interest in the affairs of Committee D-1 be immediately appointed an "adviser." The duties of such advisers would be as follows:

(*a*) To review annually all existing standards for which the subcommittee in question, during its life, was responsible.

(*b*) To report at the spring and annual meetings in the same manner as do subcommittee chairmen, upon the standards under their jurisdiction, and to call attention of Committee D-1 to any developments that might necessitate alteration of an existing standard for which a discharged subcommittee had been responsible, and to request in such an event the reappointment of a subcommittee to give the matter consideration.

(*c*) To retain a list of members of the subcommittee at the time of its discharge, in order to communicate with them in the event change in a standard in which they had an interest was to be given consideration.

(*d*) To give consideration to questions pertaining to the standards under their jurisdiction that are received from time to time by the office of the Secretary.

Respectfully submitted on behalf of the special committee,

M. REA PAUL,
Chairman.

REPORT OF COMMITTEE D-2 ON PETROLEUM PRODUCTS AND LUBRICANTS

Committee D-2 on Petroleum Products and Lubricants held three regular meetings during the past year (in June at Detroit, Mich., in January at New York, N. Y., and in March at Pittsburgh, Pa.) and also an informal meeting in November in Los Angeles, Calif., at the time of the annual meeting of the American Petroleum Institute.

Acting as Sectional Committee Z11 on Methods of Testing Petroleum Products and Lubricants, functioning under the procedure of the American Standards Association, the following recommendations in connection with American Standards and Tentative Standards were made during the year:

Approval of Revision of American Standards:

- Method of Test for Dilution of Crankcase Oils (D 322 - 35) (A.S.A. No. Z11.29-1935)
- Method of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (D 86 - 35) (A.S.A. No. Z11.10-1935)
- Method of Test for Precipitation Number of Lubricating Oils (D 91 - 35) (A.S.A. No. Z11.30-1935)
- Method of Test for Water and Sediment in Petroleum Products by Means of Centrifuge (D 96 - 35) (A.S.A. No. Z11.8-1935)

Approval of Revision of American Tentative Standard:

- Definitions of Terms Relating to Petroleum (D 288 - 35 T) (A.S.A. No. Z11.28-1935)

Approval of A.S.T.M. Standards as American Standards:

- Method of Test for Distillation of Crude Petroleum (D 285 - 33) (A.S.A. No. Z11.32-1935)
- Methods for Sampling Petroleum and Petroleum Products (D 270 - 33) (A.S.A. No. Z11.33-1935)

Approval of A.S.T.M. Tentative Standards as American Tentative Standards:

- Method of Test for Color of Lubricating Oils by Means of A.S.T.M. Union Colorimeter (D 155 - 34 T) (A.S.A. No. Z11.34-1935)
- Method of Test for Color of Refined Petroleum Oil by Means of Saybolt Chromometer (D 156 - 34 T) (A.S.A. No. Z11.35-1935)
- Method of Test for Gum Content of Gasoline (D 381 - 34 T) (A.S.A. No. Z11.36-1935)
- Method of Test for Knock Characteristics of Motor Fuels (D 357 - 34 T) (A.S.A. No. Z11.37-1935)
- Method of Test for Sulfur in Petroleum Oils by Lamp Method (D 90 - 34 T) (A.S.A. No. Z11.38-1935)
- Viscosity-Temperature Chart for Liquid Petroleum Products (D 341 - 32 T) (A.S.A. No. Z11.39-1935)

These recommendations have been approved by the American Standards Association with A.S.A. numbers as indicated.

A new Sectional Committee Z11 on Petroleum Products and Lubricants has been organized under the procedure of the American Standards Association, with the A.S.T.M. as sponsor. The scope of the new committee includes specifications as well as methods of test and nomenclature, and Committee D-2 will no longer function as a sectional committee.

Acting on the recommendation of Committee D-2,[1] Committee E-10 on Standards on August 22, 1935, accepted for publication the Tentative Method of Test for Vapor Pressure of Motor and Aviation Gasoline (Reid Method) (D 417 – 35 T), a tentative revision of Standard Method of Test for Gravity of Petroleum and Petroleum Products by Means of the Hydrometer (D 287 – 33), and a revision of the Tentative Definitions of Terms Relating to Petroleum (D 288 – 35 T).

The voting membership of Committee D-2 now consists of 40 producer, 31 consumer, and 16 general interest members.

ACTIVITIES OF SUBCOMMITTEES AND TECHNICAL COMMITTEES

Subcommittee IV on Grease (R. R. Matthews, chairman) is studying dropping-point methods with the expectation of submitting a procedure for publication as tentative. The subcommittee is also considering a modification of the grease worker specified in the Tentative Method of Test for Penetration of Greases and Petrolatums (D 217 – 33 T) to overcome some of the difficulties that have been encountered, and also the development of a satisfactory procedure for the consistency of soft greases.

With respect to the Standard Methods of Analysis of Grease (D 128 – 27), the subcommittee is making a study of the time factor and the solvent in the determination of water and also of the use of Alkali Blue 6B as an indicator in determining acidity.

Subcommittee V on Viscosity (J. C. Geniesse, chairman) has prepared descriptions of methods of determining kinematic viscosity by two types of instruments (suspended-level and modified Ostwald) and of converting kinematic viscosity to Saybolt Universal viscosity. These methods are published as information in Appendices I, II, and III to this report.

Subcommittee VI on Color (H. M. Hancock, chairman) has submitted a statement on the Development of Color Standards for the A.S.T.M. Union Colorimeter which appears in Appendix IV.

Subcommittee XIII on Neutralization Number and Saponification (E. B. McConnell, chairman) and a joint committee of Committee D-2 and Committee D-9 on Electrical Insulating Materials have prepared a potentiometric method for determining neutralization number of petroleum products and lubricants. This method is published as information in Appendix V.

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[1] In submitting these recommendations to Committee E-10 on Standards, Committee D-2 reported the following results of the letter ballot vote of a total of 65 ballots returned from a voting membership of 85: Method D 417 – 35 T, affirmative 56, negative 0, ballots marked "not voting" 9; Method D 287 – 33, affirmative 61, negative 1, ballots marked "not voting" 3; Definitions D 288 – 35 T, affirmative 60, negative 1, ballots marked "not voting" 4.

Section IV on Crankcase Oil Service Changes (L. L. Davis, chairman) of Technical Committee B on Motor Oils, has prepared suggested uniform automotive engine lubrication recommendations, published as information in Appendix VI.

Technical Committee C on Fuel Oils (Including Diesel Fuels) (M. J. Reed, chairman) has prepared a revision of the Classification of Diesel Fuels, contained in Appendix VII and also published as information.

RECOMMENDATIONS AFFECTING STANDARDS

I. Proposed Revisions of Standards:

The committee recommends the revision of five standard methods, as indicated below, to become effective immediately. Accordingly, the necessary nine-tenths vote at the annual meeting is requested in order that these revisions may be referred to letter ballot of the Society.

Standard Method of Test for Burning Quality of Kerosine Oils (D 187 – 30).[1]—The following changes in the requirements for the burner are recommended by Subcommittee XIX on Illuminating Oils (J. B. Rather, chairman). These changes are necessitated by the fact that burners meeting the present specifications are no longer obtainable; they do not affect the results obtained in the test.

Section 3.—Change to read as follows:

3. *Miller No. 2 Sun Hinge Burner* (See Fig. 2) or any other burner conforming to the following requirements:

UPPER PART OF BURNER:	INCHES	CENTIMETERS	TOLERANCES, CM.
Thickness of metal........No. 26 ± 1 B. & S. gage			
Height of cone from base of cone (outside).......	1.20	3.05	±0.10
Inside diameter of cone at base measured at base in constriction..............................	1.77	4.50	±0.15
Inside diameter of cone at base of flame spreader:			
(1) parallel to slot.........................	1.42	3.60	±0.10
(2) perpendicular to slot....................	1.42	3.60	±0.10
Height of cone from base to a point:			
(1) 1 cm. right of center....................	1.15	2.92	±0.10
(2) 1 cm. left of center......................	1.15	2.92	±0.10
Over-all diameter of flame spreader at base.......	2.79	7.08	±0.20
Height of collar at flame-spreader base...........	0.31	0.79	±0.10
Diameter of scallops..............................	0.21	0.54	±0.10
Depth of scallops.................................	0.08	0.20	±0.05
Center of screw to bottom of collar (outside)......	0.29	0.73	±0.10
Holes at base of spreader, 28 in number:			
(1) diameter.....................................	0.09	0.24	±0.05
(2) spacing, edge to edge.......................	0.14	0.35	±0.10
Space at back of flame-spreader collar (without holes), distance between edges of holes.........	0.83	2.10	±0.10
Space at front of flame-spreader collar (without holes), distance between edges of holes.........	0.61	1.56	±0.10
Width of flame-spreader slot at top:			
(1) center...	0.39	1.00	±0.05
(2) 1 cm. to left of center......................	0.39	1.00	±0.05
(3) 1 cm. to right of center.....................	0.39	1.00	±0.05
Width of wick holder (outside)...................	0.96	2.44	±0.10
Depth of wick holder (outside)...................	0.17	0.44	±0.05

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 742.

UPPER PART OF BURNER (*Continued*):	INCHES	CENTIMETERS	TOLERANCES, CM.
Length of wick holder	1.75	4.45	±0.10
Width of air vent (outside)	0.34	0.87	±0.05
Depth of air vent (outside)	0.08	0.20	±0.05
Length of air vent	1.67	4.25	±0.10
Top of wick holder to base of flame-spreader slot	0.10	0.25	±0.10
Base of flame-spreader slot (inside) to edge of wick holder (outside):			
(1) right	0.23	0.59	±0.10
(2) left	0.23	0.59	±0.10
Edge of flame-spreader slot (top center) to top center edge of wick holder	0.57	1.44	±0.10
Wick holder—to run approximately parallel to flame-spreader slot.			
LOWER PART OF BURNER:			
Diameter at widest point (parallel to slot)	2.22	5.64	±0.15
Diameter at first constriction	2.18	5.53	±0.15
Diameter at second constriction	1.96	4.97	±0.15
Diameter at third constriction	1.42	3.60	±0.15
Bottom-threaded to fit standard brass Saybolt test lamp.			
Ventilating openings (12 in number, ±1) width:			
(1) center (approximate dimensions)	0.29	0.73	......
(2) top and bottom (approximate dimensions)	0.21	0.54	......
Ventilating openings, height:			
(1) center (approximate dimensions)	0.24	0.61	......
(2) sides (approximate dimensions)	0.28	0.72	......
Top of wick holder to top of holder support	1.02	2.60	±0.10
Top of lower part of burner to fourth constriction	0.63	1.60	±0.15
SCREEN:			
Diameter of screen—sufficient to fit wick holder support:			
Diameter of holes in screen	0.05	0.12	±0.05
Number of holes in screen per square centimeter	45, with a tolerance of 11.		
Screen to fit snugly around wick holder and air vent.			

NOTE.—The burner shall be used as received from the supplier provided it meets the above requirements and is free from gross imperfections of manufacture. It shall be clean and in good condition at the start of the test but emery paper shall not be used in cleaning, nor imperfections removed by means of a file or otherwise.

Standard Method of Test for Burning Quality of Long-Time Burning Oil for Railway Use (D 219 - 30).[1]—The following changes in the requirements for the burner are recommended by Subcommittee XIX on Illuminating Oils (J. B. Rather, chairman). These changes are necessitated by the fact that burners meeting the present specifications are no longer obtainable; they do not affect the results obtained in the test.

Section 4.—Change the following dimensions of the burner to read as follows by the addition of the italicized figures and the omission of those in brackets:

	INCHES	CENTIMETERS	TOLERANCES, CM.
Width of top of V-shaped slots in flame spreader	[0.31] *0.27*	[0.79] *0.69*	±0.08
Rectangular Openings, four in number:			
(1) Height	[0.44] *0.40*	[1.11] *1.02*	±0.08
(2) Width	[0.56] *0.53*	[1.43] *1.35*	±0.08

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 748.

Standard Method of Test for Carbon Residue of Petroleum Products (Conradson Carbon Residue) (*D 189 - 30*).[1]—The following changes are recommended by Subcommittee XXIII on Carbon Residue (L. C. Beard, Jr., chairman). The addition to Section 2 (*f*) presents a desirable alternate form of construction of the apparatus.

Section 2 (*f*).—Change to read as follows by the addition of the italicized words:

> (*f*) Asbestos block, ***refractory ring***, or hollow sheet-metal box, 150 to 175 mm. (6 to 7 in.) in diameter if round or on a side if square 32 to 38 mm. (1¼ to 1½ in.) in thickness, provided with a metal-lined, inverted cone-shaped opening through the center; 83 mm. (3¼ in.) in diameter at the bottom, and 89 mm. (3½ in.) in diameter at the top.

Section 4.—Add a new Section 4 reading as follows, renumbering the present Section 4 as Section 5.

> *4. Special Procedure for Oils Having Carbon Residues in Excess of Five Per Cent, Such as Heavy Crude Oils, Residuums, Heavy Fuel Oils, and Heavy Gas-Enrichment Oils.*—When the carbon residue as obtained by the above procedure (using a 10-g. sample) is in excess of 5 per cent, difficulties may be experienced due to boiling over of the sample. Trouble also may be encountered with samples of heavy products which are difficult to dehydrate. In the case, therefore, of samples showing by the usual method of test a carbon residue in excess of 5 per cent, the test shall be repeated in duplicate using a 5-g. sample.

Standard Method of Test for Steam Emulsion of Lubricating Oils (*D 157 - 28*).[2]—To obtain better reproducibility of results with this test, Subcommittee XI on Turbine Oils (J. A. Capp, chairman) has recommended the inclusion of further details in the method respecting the dimensions of the oil container, steam pipe and steam delivery tube. In addition, a number of editorial improvements in the text were also considered desirable and these changes have accordingly been incorporated in the revised method appended hereto.[3]

Standard Abridged Volume Correction Table for Petroleum Oils (*D 206 - 34*).[4]—The following revisions are recommended by the Special Subcommittee on Volume Correction Tables (E. W. Dean, chairman): (*a*) Replacement of present Group 0 multipliers with multipliers corresponding to a base coefficient of 0.00035; (*b*) extension of multipliers of Group 1 to 499 F., and (*c*) extension of multipliers of Groups 4, 5, and 6 from 99 to 124 F. These proposed changes and extensions to the standard tables are appended hereto.[5] In addition, the following revision in the text of the tables is desirable:

Delete the second paragraph which reads as follows:

> This abridged table includes all of the figures appearing in the table as issued in 1925, and, in addition, two new groups. The figures for Group 0 are based on Table I of the Bureau of Standards *Miscellaneous Publication No. 97*, and the figures for

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 757.

[2] *Ibid.*, p. 795.

[3] See 1936 Book of A.S.T.M. Standards, Part II, p. 887.

[4] 1934 Supplement to Book of A.S.T.M. Standards, p. 127.

[5] The changes have been incorporated in the revised standard tables which appear in the 1936 Book of A.S.T.M. Standards, Part II, p. 988.

> Group 7 are based on the Bureau of Standards *Circular No. 154.* This extension of the original abridged table has been rendered necessary on account of the growing importance of very heavy and very light petroleum products.

and in place thereof add the following as a footnote:

> This abridged table differs from that published in 1934 in three respects: The multipliers for Group 0 have been revised slightly; Group 1 has been extended from 249 to 499 F.; and Groups 4, 5, and 6 have been extended from 99 to 124 F.
>
> The multipliers in the Group 0 table in the 1934 standard were taken from the National Bureau of Standards *Miscellaneous Publication No. 97.* With the revision of *Circular No. 154* (published as *Circular No. 410*) to include data on oils from 0 to 10° A.P.I., it has seemed desirable to employ the procedure followed in the other groups and choose the column of multipliers from the unabridged table which has a base coefficient of expansion nearest 0.00035, which in the case of Group 0 is the column corresponding to a gravity of 6° A.P.I.

II. Proposed Revision of Tentative Standard:

The committee recommends the revision of one tentative standard as indicated below:

Tentative Method of Test for Knock Characteristics of Motor Fuels (D 357 – 34 T).[1]—The following revision is recommended by Technical Committee A on Gasoline (C. B. Veal, chairman):

Section 6.—Insert the following new Paragraph (*f*) and reletter the remaining paragraphs:

> (*f*) *Oil Temperature.*—The electric oil heater shall be used only to raise the oil temperature rapidly to the equilibrium operating temperature, normal operation maintaining the equilibrium thereafter. By "equilibrium" is meant that steady temperature attained by the oil upon continuous operation of the engine without the use of the heater.

III. Proposed Adoption of Tentative Revisions of Standards as Standard:

The committee recommends that the tentative revisions,[2] as proposed last year, of the following standard methods be referred to letter ballot of the Society for adoption as standard:

- Revision of Standard Method of Test for Distillation of Crude Petroleum (D 285 – 33).
- Revision of Standard Method of Test for Flash Point by Means of the Pensky-Martens Closed Tester (D 93 – 22).
- Revision of Standard Method of Test for Saponification Number (D 94 – 28).
- Revision of Standard Methods of Test for Viscosity of Petroleum Products and Lubricants (D 88 – 33), published as Tentative Method of Test for Viscosity by Means of the Saybolt Viscosimeter (D 88 – 35 T).

The committee further recommends that the tentative revisions,[3] also proposed last year, of the following two standard methods be further revised as indicated below and referred to letter ballot of the Society for adoption as standard:

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[1] *Proceedings,* Am. Soc. Testing Mats., Vol. 34, Part I, p. 902 (1934); also 1935 Book of A.S.T.M. Tentative Standards, p. 723.

[2] *Proceedings* Am. Soc. Testing Mats., Vol. 35, Part I, pp. 1400, 1401, 1402, 914, respectively (1935); also 1935 Book of A.S.T.M. Tentative Standards, pp. 1526, 1527, 1528, 769, respectively.

[3] *Proceedings,* Am. Soc. Testing Mats., Vol. 35, Part I, p. 1402 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 1528.

Revision of Standard Method of Test for Flash Point of Volatile Flammable Liquids (D 56 - 21).[1]—On the recommendation of Subcommittee XII on Flash Point (J. B. Terry, chairman), it is proposed that this revision published as the Tentative Method of Test for Flash Point by Means of the Tag Closed Tester (D 56 - 35 T) be modified as follows:

Section 12 (b).—Change from its present form: namely,

(*b*) *Thermometer.*—For determining flash points below 40 F. (4.4 C.), thermometers graduated either in Fahrenheit or Centigrade degrees, having ranges of 0 F. to 210 F., or −20 C. to +100 C., shall be used. Otherwise the thermometers shall conform to the requirements prescribed in Section 3. These thermometers may be used optionally for the determination of flash points above 40 F.

to read as follows:

(*b*) *Thermometer.*—For determining flash points below 40 F. (4.4 C.), suitable thermometers of low range shall be used. These thermometers shall conform to the requirements of Section 3 except that the ranges shall be 0 F. to 120 F. or −20 C. to +50 C. These thermometers may not be used in the testing of materials flashing above 70 F. (21.1 C.).

Section 13.—Change to read as follows by the addition of the italicized words:

13. The procedure *to be followed* shall be the same as *that* described in Sections 4 to 11, except that in determining flash points below 40 F. (4.4 C.) the bath shall be filled with brine *or other low-freezing liquid* instead of water.

Revision of Standard Method of Test for Gravity of Petroleum and Petroleum Products by Means of the Hydrometer (D 287 - 33).[2]—Modified as follows on the recommendation of Subcommittee II on Gravity (H. T. Bennett, chairman):

Section 6.—Change the marginal heading of Paragraph (*a*) to read, "Temperature of Test, Crude Petroleum and Its Products," and include additional Paragraphs (*b*) and (*c*), as follows:

(*b*) A product with initial boiling point below 250 F. (121.1 C.) and an A.P.I. gravity below 70° shall be cooled in the original closed container to a temperature of 65 F. (18.3 C.) or lower before pouring into the hydrometer cylinder. A product with an A.P.I. gravity of 70° or greater shall be cooled in the original closed container to a temperature of 35 F. (1.7 C.) or lower before pouring into the hydrometer cylinder.

(*c*) The thermometer, hydrometer, and hydrometer cylinder shall be at approximately the same temperature as the product to be tested. Precaution shall be taken to prevent the temperature of the sample from changing appreciably during the time necessary to complete the test. This may be done when testing non-volatile and non-viscous oils by choosing a temperature of test only slightly different from the room temperature. When volatile products are cooled or viscous products heated the test cylinder shall be placed in a bath maintained at a constant desired temperature during the time of test.

Change the marginal heading of Paragraph (*b*) to read "Temperature of Test, Mixtures of Petroleum and Other Substances" and redesignate it as Section 7, renumbering the remaining sections accordingly.

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 663.

[2] *Ibid.*, p. 819.

Section 7.—Delete the last sentence of the first paragraph which reads as follows:

> If the product to be tested is easily volatile the sample, thermometer, hydrometer, and hydrometer cylinder shall be cooled to a sufficiently low temperature before testing to insure that no volatile fractions are lost during the necessary handling.

Delete the first paragraph of the note at the end of Section 7 which reads as follows:

> Precautions should, of course, be taken to prevent the temperature of the sample from changing appreciably during the time necessary to complete the test. This may be done when testing non-viscous oils by choosing a temperature of test only slightly different from the room temperature. When testing viscous oils which must be heated before testing it will be necessary to surround the test cylinder with a bath maintained at a constant desired temperature during the time of test.

IV. Proposed Adoption of Tentative Standard as Standard:

The committee recommends the submission of the following tentative method to letter ballot of the Society for adoption as standard:

Tentative Method of Test for Gum Content of Gasoline (D 381 – 34 T), revised in accordance with the recommendation of Technical Committee A on Gasoline (C. B. Veal, chairman) as follows:

Section 2 (c).—Add the following sentence to this paragraph:

> The flow meter shall be calibrated when attached to the bath with the bath liquid at room temperature.

V. Proposed Withdrawal of Standards:

The committee recommends the withdrawal of the following standard methods:

Standard Method of Test for Flash Point of Volatile Flammable Liquids (D 56 – 21), to be replaced by Standard Method of Test for Flash Point by Means of the Tag Closed Tester.

Standard Method of Test for Viscosity of Petroleum Products and Lubricants (D 88 – 33), to be replaced by Standard Method of Test for Viscosity by Means of the Saybolt Viscosimeter.

VI. Tentative Standards Continued as Tentative:

Five methods of test have been tentative for a period of three years or longer without revision, as follows:

Tentative Method of Test for Neutralization Number of Petroleum Products and Lubricants (D 188 – 27 T)
Tentative Method of Test for Expressible Oil and Moisture in Paraffin Waxes (D 308 – 29 T)
Tentative Method of Test for Penetration of Greases and Petrolatum (D 217 – 33 T)
Tentative Method of Test for Vapor Pressure of Natural Gasoline (D 323 – 32 T)
Tentative Standard Viscosity-Temperature Chart for Liquid Petroleum Products (D 341 – 32 T)

The second of these methods is a highly empirical one and is used only infrequently. The other methods may be modified as a result of work now under way. It is accordingly recommended that these methods be continued as tentative.

The election of officers resulted in the selection of the present incumbents for the ensuing term of two years.

The recommendations appearing in this report have been submitted to letter ballot of the committee, which consists of 87 members; 69 members returned their ballots. The analysis of the vote of the committee is given in Table I.

TABLE I.—ANALYSIS OF LETTER BALLOT VOTE.

Items	Affirmative	Negative	Ballots Marked "Not Voting"
I. PROPOSED REVISIONS OF STANDARDS			
Test for Burning Quality of Kerosine Oils (D 187 – 30), immediate adoption	57	0	12
Test for Burning Quality of Long-Time Burning Oil for Railway Use (D 219 – 30), immediate adoption	52	0	10
Test for Carbon Residue of Petroleum Products (D 189 – 30), immediate adoption	67	0	2
Test for Steam Emulsion of Lubricating Oils (D 157 – 28), immediate adoption	62	0	7
Abridged Volume Correction Table for Petroleum Oils (D 206 – 34), immediate adoption	64	1	4
II. PROPOSED REVISION OF TENTATIVE STANDARD			
Test for Knock Characteristics of Motor Fuels (D 357 – 34 T)	56	0	13
III. PROPOSED ADOPTION OF TENTATIVE REVISIONS OF STANDARDS AS STANDARD			
Test for Distillation of Crude Petroleum (D 285 – 33)	58	1	10
Test for Flash Point by Means of Pensky-Martens Closed Tester (D 93 – 22)	66	0	3
Test for Saponification Number (D 94 – 28)	64	0	5
Test for Viscosity of Petroleum Products and Lubricants (D 88 – 33)	65	2	2
Test for Flash Point of Volatile Flammable Liquids (D 56 – 21), as revised	68	1	0
Test for Gravity of Petroleum and Petroleum Products by Means of the Hydrometer (D 287 – 33), as revised	66	1	2
IV. PROPOSED ADOPTION OF TENTATIVE STANDARD AS STANDARD			
Test for Gum Content of Gasoline (D 381 – 34 T), as revised	58	0	11
V. PROPOSED WITHDRAWAL OF STANDARDS			
Test for Flash Point of Volatile Flammable Liquids (D 56 – 21)	68	0	1
Test for Viscosity of Petroleum Products and Lubricants (D 88 – 33)	65	2	2

This report has been submitted to letter ballot of the committee, which consists of 87 members; 69 members returned their ballots, of whom 65 have voted affirmatively, and none negatively.

Respectfully submitted on behalf of the committee,

T. A. BOYD,
Chairman.

R. P. ANDERSON,
Secretary.

EDITORIAL NOTE

Subsequent to the annual meeting Committee D-2 on Petroleum Products and Lubricants presented to the Society on August 26, 1936, through Committee E-10 on Standards a revision of the Tentative Definitions of Terms Relating to Petroleum (D 288 – 35 T), comprising a modification of the definition for petroleum lubricating grease. The revision was accepted by Committee E-10 and the definitions in their revised form appear on p. 857.

APPENDIX I

PROPOSED METHOD OF TEST FOR KINEMATIC VISCOSITY BY MEANS OF THE SUSPENDED LEVEL VISCOSIMETER[1,2]

This is a **proposed method** and is published as information only. Comments are solicited and should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

> This suspended level viscosimeter and the modified Ostwald viscosimeter[3] were developed in response to a need for a more scientific and accurate method for determining viscosity than by means of the Saybolt viscosimeter. Preliminary experiments indicate that the suspended level viscosimeter is subject to much smaller error than the Saybolt instrument. In addition, it measures kinematic viscosity and, therefore, the results are more directly translatable into friction, power requirement and heat development in bearings and other lubricated surfaces.

1. *Scope.*—(*a*) This method is suitable for determining the kinematic viscosity of any petroleum product or lubricant which is a true viscous liquid at the temperature of the test.

(*b*) The useful range of viscosities that may be measured with a given instrument depends on the capillary diameter. The viscosity ranges for the recommended capillary diameters are given in Table II.

2. *Apparatus.*—The apparatus shall consist of one or more calibrated viscosimeters, bath, thermometers and timer conforming to the requirements specified in the following Paragraphs (*a*) to (*d*):

(*a*) *Viscosimeters.*—The viscosimeters (illustrated in Fig. 1 (*a*) and (*b*)) shall be of glass and shall conform to the requirements in Table I. Figure 1 (*a*) shows an instrument with one capillary. Figure 1 (*b*) shows an alternative form of the viscosimeter in which two capillaries of different sizes are mounted in the same apparatus, which in effect increases the range available in a given bath.

TABLE I.

Over all length, mm	300 to 340
Length of capillary, mm	115 to 125
Length from center of bulb B to bottom of capillary, mm	140 to 150
Volume between marks, ml	3.60 to 3.90
Outside diameter of bulb C, mm	10 to 14
Outside diameter of bulb A, mm	20 to 30
Length of bulb A, mm	70 to 80
Inside diameter of tubes 1 and 4, mm	8 to 10
Inside diameter of tubes 2 and 3, mm	4 to 5
Inside diameter of tube 5, mm	10 to 15

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[1] Under the standardization procedure of the Society, this proposed method is under the jurisdiction of the A.S.T.M. Committee D-2 on Petroleum Products and Lubricants.

By publication of this method, the American Society for Testing Materials does not undertake to insure any one utilizing the method against liability for infringement of Letters Patent nor assume any such liability.

[2] For further details of this method, reference should be made to the following articles:

C. G. Fitzsimons, "A Rapid Precision Viscosimeter," *Industrial and Engineering Chemistry*, Analytical Edition, Vol. 7, p. 345 (1935).

L. Ubbelohde, "The Simplest and Most Accurate Viscometer and Other Instruments with Suspended Level," *Journal*, Inst. Petroleum Technologists, Vol. 19, p. 376 (1933).

L. Ubbelohde, "The Suspended Level Viscometer," *Journal*, Inst. Petroleum Technologists, Vol. 22, p. 37 (1936).

[3] See p. 399.

VISCOSIMETER	CAPILLARY DIAMETER, MM.	APPROXIMATE CALIBRATION CONSTANT, c [a]
No. 1	0.42–0.44	0.003
No. 2	0.78–0.84	0.035
No. 3	1.02–1.08	0.10
No. 4	1.28–1.36	0.25
No. 5	1.92–2.00	1.2

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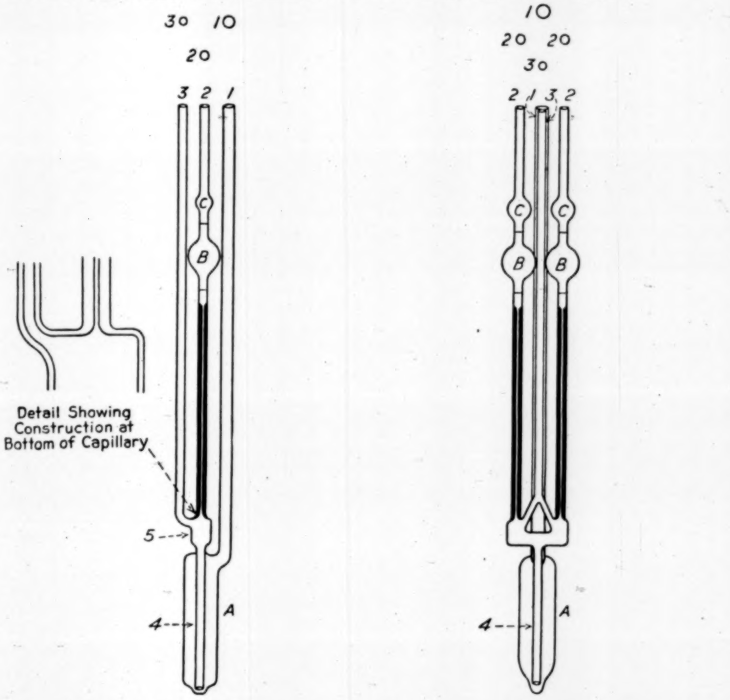
[a] The correct calibration constant depends on the actual dimensions of the instruments and therefore must be determined by experiment. The values in the above table serve as a guide only.



(a) Instrument with One Capillary Tube. (b) Instrument with Two Capillary Tubes.

FIG. 1.—Suspended Level Viscosimeter.

Viscosimeter No. 1 is necessary for low-viscosity products such as kerosines and light fuel oils. The viscosimeter with larger capillaries (viscosimeters Nos. 2 to 5) cover the range of viscosities usually encountered with lubricating oils. All instruments shall be used only at efflux times greater than 80 sec. There is no upper limit for the efflux time; however, in order to save time it is suggested that a viscosimeter be selected in which the efflux time will be less than 700 sec. The approximate viscosities corresponding to these efflux times for the five viscosimeters (Note) are given in Table II.

TABLE II.

VISCOSIMETER	EFFLUX TIME, SEC.	APPROXIMATE VISCOSITY	
		CENTISTOKES	SAYBOLT UNIVERSAL, SEC.
No. 1	80 to 700	0.5 to 4.5	......
No. 2	80 to 700	3.0 to 20	37 to 100
No. 3	80 to 700	9 to 70	55 to 320
No. 4	80 to 700	20 to 175	100 to 800
No. 5	80 to 700	100 to 850	460 to 4000

NOTE.—In case the amount of testing does not warrant installation of five viscosimeters it is possible, with equal accuracy, to make use of longer times of outflow, thereby eliminating one or more. For instance, viscosimeter No. 2 may serve for viscosities varying from 3.0 to 20 centistokes and No. 4 from 20 to 850 centistokes, thus making it unnecessary to install viscosimeters Nos. 3 and 5.

(*b*) *Bath.*—A bath suitable for immersion of the viscosimeter to within 5 cm. of the top, with provision for visibility of the instrument and the thermometer, shall be provided. The viscosimeter may be sealed in as an integral part of the bath. The thermometer shall be mounted with the bulb near the center of the viscosimeter. The bath shall be regulated so that the variation in the thermometer reading does not exceed 0.05 F. (0.03 C.). Either a liquid bath with thermostatic regulation and stirrer or a vapor bath with pressure regulation is permissible, the following materials being satisfactory for the purpose indicated:

BATH TEMPERATURE	LIQUID BATH	VAPOR BATH
100 F. (38 C.)...............	Water	Methylene chloride
210 F. (99 C.)...............	White oil Ethylene glycol	Tertiary amyl alcohol

(*c*) *Thermometers.*—In order to obtain extremely accurate results it is necessary to use thermometers accurate to 0.05 F. (0.03 C.). Thermometers of such accuracy are in the process of development and will be specified when available. In the meantime oil-tube thermometers as specified in Section 2 (*d*) of the Standard Method of Test for Viscosity by Means of the Saybolt Viscosimeter (A.S.T.M. Designation: D 88) of the American Society for Testing Materials[1] shall be used.

(*d*) *Timer.*—The stop watch or other timing device used shall be graduated in divisions of 0.2 sec. or less, and shall be accurate to within 0.1 per cent when tested over a 60-min. period (Note).

NOTE.—Electrical timing devices are permissible provided they are accurate and capable of being read to 0.2 sec. Timing devices actuated by synchronous motors shall be used only on electric circuits of controlled frequency.

3. *Procedure.*—(*a*) The proper viscosimeter, according to Table II, shall be selected. The viscosimeter shall be cleaned by rinsing twice with petroleum ether, benzol, or a narrow cut of naphtha. This solvent shall then be removed by passing a current of air through the viscosimeter and for this reason the solvent used must be of such volatility that it will be easily and completely removed under these conditions.

NOTE 1.—The instrument may be left in place in the bath, in which case the oil from the previous determination shall be withdrawn by suction through tube 3, after which portions of naphtha shall be successively introduced into tube 1, drawn up into tube 2 several times and removed by suction through tube 3. The tubes shall then be dried of naphtha by passing air through them.

NOTE 2.—Periodically, or whenever the appearance of the viscosimeter indicates the need of it, the instrument shall be cleaned by use of chromic acid which shall be allowed to stand in the tube for several hours, followed by thorough rinsing first with distilled water, then with C.P. acetone and drying by air current.

(*b*) The viscosimeter shall be adjusted to a vertical position. This may be accomplished by visual examination in two different vertical planes or by employing a small plumb bob consisting of a 1-cm. length of solder wire and a piece of silk thread attached to a perforated cork placed in the wide arm of the instrument. When properly aligned the plumb bob will not touch the walls.

(*c*) A small sample of oil (about 10 ml.) shall be filtered through a fritted (sintered) glass filter of medium porosity or a 100-mesh screen filter into a small beaker or bottle.

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 982.

The oil sample as well as the viscosimeter must be free from any solid particles, lint, etc. The oil shall be charged into tube 1 of the viscosimeter.

(*d*) The bath shall be maintained at the temperature of test within 0.05 F. The viscosimeter shall remain in the constant-temperature bath long enough to reach the bath temperature. The minimum time required is 5 min. for the 100 F. (38 C.) bath, and 10 min. for the 210 F. (99 C.) bath.

(*e*) After the sample has attained bath temperature, tube 3 shall be stoppered with the finger and the oil shall be drawn into tube 2 by suction to some point above the upper mark but not above the center of the small bulb. (When using the double instrument, the tube 2 not being used must be closed as well as tube 3.)

(*f*) The suction shall then be released and the finger removed from tube 3, allowing the oil to flow freely out of the capillary tube. The time in seconds required for the meniscus to pass from the upper to the lower mark shall be measured. If this efflux time is less than 80 sec., the next smaller viscosimeter shall be selected and the operation repeated. Determinations shall be repeated until two successive efflux times agree within 0.2 per cent, the average of these two determinations being used for calculating the kinematic viscosity.

4. *Reporting Results.*—The kinematic viscosity in centistokes shall be calculated from the following equation:

$$V = Ct - \frac{1.0}{t} \quad \text{(1)}$$

where V = the kinematic viscosity in centistokes,
t = the efflux time in seconds, and
C = the determined calibration constant for the instrument.

NOTE 1.—The value $\frac{1.0}{t}$ is the correction for kinetic energy, the constant 1.0 being determined by the design of the instrument.

NOTE 2.—For routine use a tabulation in which the kinematic viscosity is shown for integral efflux times over the range used shall be prepared for each instrument based on Eq. 1 and on the experimental constant for the instrument. Interpolation tables should also be shown.

5. *Calibration.*—The viscosimeters shall be calibrated in accordance with one of the following methods. The constant found at 100 F. shall be valid for use at other temperatures also.

(*a*) Determination of outflow time of oil standards obtained from the American Petroleum Institute or National Bureau of Standards and calculation of the calibration constant C by substituting the outflow time and the kinematic viscosity of the oil standard in Eq. 1 and solving for the value of C.

(*b*) The efflux time for pure distilled water at 100.0 F. shall be determined in Viscosimeter No. 1. The calibration constant C (water) shall be calculated as follows:

$$C\ (\text{water}) = \frac{0.689}{t} + \frac{1.0}{t^2}$$

The constant C for oils shall then be calculated by multiplying C (water) by 1.0035.

NOTE.—The value 0.689 centistokes for the kinematic viscosity of water at 100 F. is based on a value of 0.684 for the absolute viscosity. The factor 1.0035 is employed to correct for the difference in surface tension of oil and water. The value 1.0 in the above equation is the kinetic energy correction.

An oil which gives an efflux time at 100.0 F. of not less than 150 sec. in viscosimeter No. 2 shall be used for inter-comparison. The kinematic viscosity of this oil shall be determined in viscosimeter No. 1, using the value for C (for use with oils) as defined above. The efflux time at 100 F. for this oil shall then be determined in viscosimeter No. 2, from which the constant for viscosimeter No. 2 shall be calculated by use of the following general equation:

$$C = \frac{\text{Kinematic viscosity of oil used}}{t} + \frac{1.0}{t^2} \qquad (2)$$

The calibration constant of the other viscosimeters shall be similarly determined by comparison with viscosimeter No. 2, using oils whose efflux times in the instrument being calibrated are not less than 150 sec. The equivalent operation of calibrating viscosimeter No. 4 from No. 3 and viscosimeter No. 5 from No. 4 may be used as an alternative.

APPENDIX II

PROPOSED METHOD OF TEST FOR KINEMATIC VISCOSITY BY MEANS OF THE MODIFIED OSTWALD VISCOSIMETER[1,2]

This is a **proposed method** and is published as information only. Comments are solicited and should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

This modified Ostwald viscosimeter and the suspended level viscosimeter[3] were developed in response to a need for a more scientific and accurate method for determining viscosity than by means of the Saybolt viscosimeter. Preliminary experiments indicate that the Ostwald viscosimeter is subject to much smaller error than the Saybolt instrument. In addition, it measures kinematic viscosity and, therefore, the results are more directly translatable into friction, power requirement and heat development in bearings and other lubricated surfaces.

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1. *Scope.*—(*a*) This method is suitable for determining the kinematic viscocity of any petroleum product or lubricant which is a true viscous liquid at the temperature of the test.

(*b*) The useful range of viscosities that may be measured with a given instrument depends on the capillary diameter. The viscosity ranges for the recommended capillary diameters are given in Table II.

2. *Apparatus.*—The apparatus shall consist of one or more calibrated viscosimeters, bath, thermometers and timer conforming to the requirements specified in the following Paragraphs (*a*) to (*d*):

(*a*) *Viscosimeters.*—The viscosimeters (illustrated in Fig. 1) shall be of glass and shall conform to the following dimensional requirements:

TABLE I.

Over-all length, mm.		240 to 260
Length of capillary, mm.		70 to 75
Volume of bulbs *A* and *B*, each, ml.		3.0 to 3.3
Distance from center of bulb *B* to center of bulb *C*, mm.		85 to 95
Inside diameter of bulb *C*, mm.		28 to 30
Inside diameter of tube 1, mm.		8 to 12
Inside diameter of tube 2, mm.		1.5 to 2.5
Inside diameter of tube 3, mm.		3 to 5
Capillary diameter, mm.	Viscosimeter No. 100	0.60 to 0.65
	Viscosimeter No. 200	0.97 to 1.03
	Viscosimeter No. 300	1.20 to 1.30
	Viscosimeter No. 400	1.80 to 1.90

Each viscosimeter shall be so constructed that a line drawn vertically through the center of bulbs *A* and *B* will pass through the center of bulb *C* (Fig. 1).

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[1] Under the standardization procedure of the Society, this proposed method is under the jurisdiction of the A.S.T.M. Committee D-2 on Petroleum Products and Lubricants.

[2] For further details of this method, reference should be made to "Viscosity Standardization of Petroleum Lubricating Fractions" by M. R. Cannon and M. R. Fenske, *Oil and Gas Journal*, Vol. 33, p. 52, April 11 (1935); and "Simple Viscometers and Auxiliary Equipment for the Accurate Measurement of Viscosity in Fundamental Units" by M. R. Cannon and M. R. Fenske, *Oil and Gas Journal*, Vol. 34, p. 45, April 9 (1936).

[3] See p. 394.

The four viscosimeters specified will conveniently cover the range of viscosities usually encountered with lubricating oils. They shall be used only at times of efflux greater than 200 sec. for the No. 100 series and greater than 100 sec. for the larger sizes. There is no upper limit for the efflux time; however, in order to save time it is suggested that a viscosimeter be selected in which the efflux time will be less than 700 sec. The approximate viscosities corresponding to these efflux times for the four viscosimeters are given in the following table:

TABLE II.

VISCOSIMETER	EFFLUX TIME, SEC.	APPROXIMATE VISCOSITY	
		CENTISTOKES	SAYBOLT UNIVERSAL, SEC.
No. 100	200 to 700	3 to 10	35 to 65
No. 200	100 to 700	10 to 70	60 to 325
No. 300	100 to 700	25 to 175	120 to 800
No. 400	100 to 700	120 to 850	550 to 4000

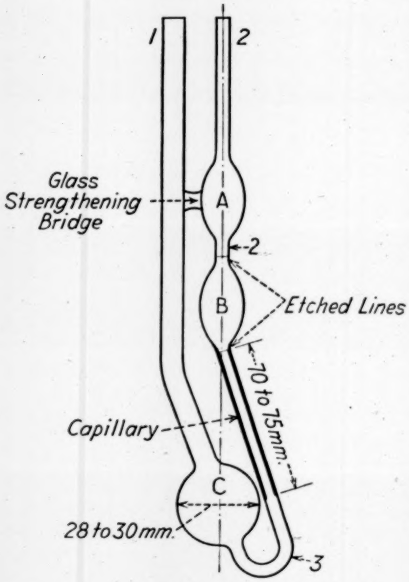

FIG. 1.—Modified Ostwald Viscosimeter.

In case the amount of testing does not warrant installation of four viscosimeters it is possible, with equal accuracy, to make use of longer times of outflow, thereby eliminating one or more. For instance, viscosimeter No. 100 may serve for viscosities varying from 3 to 25 centistokes and No. 300 for viscosities from 25 to 850 centistokes, thus making it unnecessary to install viscosimeters Nos. 200 and 400. In case a special viscosity range is desired reference should be made to Supplement A.

(*b*) *Bath.*—A bath suitable for immersion of the viscosimeter to within 5 cm. of the top, with provision for visibility of the instrument and the thermometer, shall be provided. The thermometer shall be mounted with the bulb near the center of the viscosimeter. The bath shall be regulated so that the variation in the thermometer reading does not exceed 0.05 F. (0.03 C.). Either a liquid bath with thermostatic regulation and stirrer or a vapor bath with pressure regulation is permissible, the following materials being satisfactory for the purpose indicated:

BATH TEMPERATURE	LIQUID BATH	VAPOR BATH
100 F. (38 C.)...............	Water	Methylene chloride
210 F. (99 C.)...............	White oil Ethylene glycol	Tertiary amyl alcohol

(*c*) *Thermometers.*—In order to obtain extremely accurate results it is necessary to use thermometers accurate to 0.05 F. (0.03 C.). Thermometers of such accuracy are in the process of development and will be specified when available. In the meantime oil-tube thermometers as specified in Section 2 (*d*) of the Standard Method of Test for Viscosity by Means of the Saybolt Viscosimeter (A.S.T.M. Designation: D 88) of the American Society for Testing Materials[1] shall be used.

(*d*) *Timer.*—The stop watch or other timing device used shall be graduated in divisons of 0.2 sec. or less, and shall be accurate to within 0.1 per cent when tested over a 60-min. period (Note).

NOTE.—Electrical timing devices are permissible provided they are accurate and capable of being read to 0.2 sec. Timing devices actuated by synchronous motors shall be used only on electric circuits of controlled frequency.

3. *Procedure.*—(*a*) The proper viscosimeter, according to Table II, shall be selected. The viscosimeter shall be cleaned by rinsing twice with petroleum ether, benzol, or a narrow cut of naphtha. This solvent shall then be removed by passing a current of air through the viscosimeter and for this reason the solvent used must be of such volatility that it will be easily and completely removed under these conditions.

(*b*) A small sample of oil (about 10 ml.) shall be filtered through a fritted (sintered) glass filter of medium porosity or a 100-mesh screen filter into a small beaker or bottle. The oil sample as well as the viscosimeter must be free from any solid particles, lint, etc.

(*c*) The oil at a temperature of 70 to 90 F. (21 to 32 C.) shall be charged into the viscosimeter in the following manner: The instrument shall be held in an inverted vertical position with the end of the capillary arm immersed in the oil. Both bulbs on the capillary side of the viscosimeter shall be filled with oil by suction, and the oil brought into the working capillary up to the mark etched on it. Care shall be used that the rubber tubing employed in applying the suction shall be clean.

(*d*) After loading, the excess oil shall be wiped off the top of the viscosimeter and it shall then be placed in the constant temperature bath. It shall be immersed in the bath liquid to within 5 cm. of the top.

NOTE.—A convenient way to support the viscosimeter in the bath is to clamp a rubber stopper on the instrument and to provide the cover of the constant-temperature bath with holes to receive the rubber stopper. A No. 10 rubber stopper with a 1.0-cm. hole and with a section 0.5 cm. in width cut out from the opening to the side of the stopper is suggested.

(*e*) The viscosimeter shall be adjusted to a vertical position. This may be accomplished by visual examination in two different vertical planes or by employing a small plumb-bob consisting of a 1-cm. length of solder wire and a piece of silk thread attached to a perforated cork placed in the wide arm of the instrument. When properly aligned the plumb bob will not touch the walls.

(*f*) The viscosimeter shall remain in the constant-temperature bath long enough to reach the bath temperature. The minimum time required is 5 min. for the 100 F. (38 C.) bath, and 10 min. for the 210 F. (99 C.) bath.

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 982.

(*g*) During the heating stage the oil will drain from the upper bulbs into the lower reservoir and in the course of this operation a bubble of air may be trapped in the bend at the bottom of the instrument. When the oil level is brought to the etched line between the bulbs this air shall be removed, so that there will be an unbroken column of oil extending from the lower reservoir through the capillary during the test.

(*h*) After the sample has attained bath temperature, suction shall be applied to the capillary arm to draw the oil sample up to a point about 5 mm. above the mark between the bulbs. The suction shall then be released thereby opening this arm to the atmosphere. The time for the meniscus to pass from the upper to the lower mark shall be measured.

(*i*) The viscosity of the oil in centistokes shall then be obtained by multiplying the efflux time by the viscosimeter constant.

(*j*) A check determination shall be made by again drawing the oil sample above the etched line between the bulbs and timing as before. In careful work it may be desirable to run the same oil in two different viscosimeters.

NOTE.—An experienced operator can run six or more viscosimeters at one time. During the preheating stage of one viscosimeter, another instrument may be loaded or cleaned so that no time is lost. Small (10-in. diameter) constant-temperature baths will hold six or more viscosimeters.

4. *Reporting Results.*—The kinematic viscosity in centistokes shall be calculated from the following equation:

$$V = Ct$$

where V = the kinematic viscosity in centistokes,
t = the efflux time in seconds, and
C = the determined calibration constant for the instrument.

5. *Calibration.*—The viscosimeter shall be calibrated in accordance with one of the following methods:

(*a*) Determination of outflow time of oil standards obtained from the American Petroleum Institute or National Bureau of Standards and calculation of the calibration constant C by substituting the outflow time and the kinematic viscosity of the oil standard in the equation given in Section 4 and solving for the value of C.

(*b*) Determination of calibration constant C by means of a master viscosimeter or calibrated instrument of this type as outlined in the references appearing in the footnote to the title of this method.

If it is desired to perform all calibrations at 100 F. (38 C.) the viscosimeter constants at 60 F. (16 C.), 130 F. (54 C.) and 210 F. (99 C.) may be obtained, as follows:

$$\text{Viscosimeter constant at 210 F. (99 C.)} = 0.996 \times \text{viscosimeter constant at 100 F. (38 C.)}.$$

$$\text{Viscosimeter constant at 130 F. (54 C.)} = 0.999 \times \text{viscosimeter constant at 100 F. (38 C.)}.$$

$$\text{Viscosimeter constant at 60 F. (16 C.)} = 1.001 \times \text{viscosimeter constant at 100 F. (38 C.)}.$$

For other temperatures reference should be made to Supplement B for the general expression giving variation in viscosimeter constant with temperature.

SUPPLEMENT A

The following table is presented to show the variation of viscosimeter constant and useful viscosity range with capillary diameter. Hence, if any particular viscosity range, other than those specified in Section 2 (*a*), is desired a viscosimeter may be selected in order most conveniently to cover this range:

CAPILLARY DIAMETER, MM.	RANGE, SEC.	APPROXIMATE RANGE, CENTISTOKES	VISCOSIMETER CONSTANT, CENTISTOKES PER SECOND
0.40	300 to 700	0.8 to 1.9	0.00265
0.60	200 to 700	2.7 to 9.3	0.0133
0.80	200 to 700	8.6 to 30	0.0427
1.00	100 to 700	10 to 70	0.100
1.20	100 to 700	22 to 150	0.217
1.40	100 to 700	40 to 280	0.400
1.60	100 to 700	67 to 470	0.667
1.80	100 to 700	110 to 750	1.07
2.00	100 to 700	170 to 1200	1.70

SUPPLEMENT B

A more general expression giving the variation in viscosimeter constant with temperature is as follows:

$$C_{T_2} = C_{T_1}\left[1 - \frac{V_2 - V_1}{0.785H\, d^2}\right]$$

where C_{T_2} = the viscosimeter constant at T_2, the temperature for which the constant is being calculated,

C_{T_1} = the viscosimeter constant at T_1, the temperature at which the constant is known,

V_2 = the total volume of liquid in the viscosimeter at T_2,

V_1 = the total volume of liquid in the viscosimeter at T_1,

H = the fluid head; for viscosimeters according to Fig. 1, this is approximately 90 mm., and

d = the inside diameter of lower reservoir; for viscosimeters according to Fig. 1, this is approximately 30 mm.

APPENDIX III

PROPOSED METHOD FOR CONVERTING KINEMATIC VISCOSITY TO SAYBOLT UNIVERSAL VISCOSITY[1]

This is a **proposed method** and is published as information only. Comments are solicited and should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

In 1932 the Society issued the Tentative Standard Viscosity-Temperature Chart for Liquid Petroleum Products (A.S.T.M. Designation: D 341 – 32 T)[2] which includes equations for converting viscosity in Saybolt Universal seconds to kinematic viscosity in centistokes. These conversion equations, although the best available at the time, have since been shown to be in error by as much as 2 per cent in some ranges. To remedy this, Subcommittee V on Viscosity (J. C. Geniesse, chairman) of Committee D-2 on Petroleum Products and Lubricants has reconsidered the problem, taking into consideration more recent and accurate data. As a result, the accompanying Table I containing data for converting kinematic viscosity in centistokes to viscosity in Saybolt Universal seconds is being published as information for use in connection with the Proposed Methods of Test for Kinematic Viscosity by Means of the Suspended Level Viscosimeter[3] and for Kinematic Viscosity by Means of the Modified Ostwald Viscosimeter.[4]

TABLE I.—CONVERSION OF KINEMATIC VISCOSITY TO SAYBOLT UNIVERSAL VISCOSITY.

At 100 F.				At 210 F.			
Kinematic Viscosity, centistokes	Saybolt Universal Viscosity, sec.	Kinematic Viscosity, centistokes	Saybolt Universal Viscosity, sec.	Kinematic Viscosity, centistokes	Saybolt Universal Viscosity, sec.	Kinematic Viscosity, centistokes	Saybolt Universal Viscosity, sec.
3	35.9	35	163.3	3	36.3	35	165.1
4	39.0	36	167.7	4	39.4	36	169.6
5	42.2	37	172.3	5	42.6	37	174.2
6	45.4	38	176.8	6	45.8	38	178.8
7	48.6	39	181.3	7	49.1	39	183.3
8	51.9	40	185.9	8	52.4	40	187.8
9	55.3	41	190.4	9	55.8	41	192.4
10	58.8	42	195.0	10	59.2	42	197.0
11	62.3	43	199.5	11	62.8	43	201.6
12	65.9	44	204.0	12	66.5	44	206.2
13	69.7	45	208.6	13	70.3	45	210.7
14	73.5	46	213.1	14	74.2	46	215.4
15	77.3	47	217.6	15	78.0	47	219.9
16	81.2	48	222.2	16	82.0	48	224.5
17	85.2	49	226.7	17	86.1	49	229.1
18	89.3	50	231.2	18	90.2	50	233.8
19	93.4	55	254.0	19	94.4	55	256.8
20	97.6	60	277.0	20	98.6	60	280.0
21	101.8	65	299.8	21	102.9	65	303.2
22	106.1	70	322.7	22	107.1	70	326.0
23	110.4	75	345.6	23	111.4	75	349.3
24	114.7	80	368.5	24	115.8	80	372.5
25	119.1	85	391.5	25	120.2	85	395.8
26	123.4	90	414.4	26	124.5	90	419.1
27	127.8	95	437.5	27	129.0	95	442.3
28	132.2	100	460.4	28	133.5	100	465.6
29	136.5			29	137.9		
30	141.0	Values above 100 centistokes at 100 F. may be estimated by the following formula: Saybolt seconds = centistokes × 4.604		30	142.4	Values above 100 centistokes at 210 F. may be estimated by the following formula: Saybolt seconds = centistokes × 4.656	
31	145.4			31	146.9		
32	149.8			32	151.5		
33	154.4			33	156.0		
34	158.8			34	160.5		

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[1] Under the standardization procedure of the Society, this proposed method is under the jurisdiction of the A.S.T.M. Committee D-2 on Petroleum Products and Lubricants.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 772 (1932); also 1936 Book of A.S.T.M. Tentative Standards, p. 666.

[3] See p. 394.

[4] See p. 399.

The conversion values at 100 F. have been derived from the average of five existing sets of conversion data and three experimental values established by cooperative work. The five sets of conversion data used for this purpose were those of (1) Standard Oil Company of New Jersey, (2) Union Oil Company of California, (3) Anglo-American Oil Company, (4) The Pennsylvania State College, and (5) the present A.S.T.M. equations.

Similarly, the conversion values at 210 F. were derived from the average of conversion data obtained from two of the above sources (whose values showed that the conversion at 100 F. was not the same as at 210 F.) and four experimental values obtained by cooperative work. The two sets of conversion data used for this purpose were those of (1) Union Oil Company of California, and (2) Anglo-American Oil Company.

In the case of the conversion values at 100 F. the maximum spread between the sets of the available conversion data was 0.5 per cent or less from 150 to 5000 Saybolt universal seconds, and at 210 F. the maximum variation was not more than 1.0 per cent. Oil samples were accordingly selected to check the values where deviations were greatest. The kinematic viscosities of these samples were obtained by four laboratories whose equipment represented the best available; all calibrations being based on a value of 1.007 centistokes for the viscosity of pure water at 20 C. The Saybolt Universal viscosities were obtained by four other laboratories whose Saybolt instruments have very small or zero correction for American Petroleum Institute oil standards Alpha 35 and Beta 35, and are therefore representative of the proposed master Saybolt viscosimeter tube. Experimental data on these oil samples are given in Table II.

TABLE II.—COOPERATIVE VISCOSITY DATA.

Oil Sample	Temperature, deg. Fahr.	Kinematic Viscosity, centistokes	Saybolt Universal Viscosity, sec.	Percentage Total Spread in Saybolt Viscosity	
				Kinematic Viscosity Results	Saybolt Universal Results
A.P.I. Alpha 35	100	63.48	293.1	0.31	0.0
137109	100	13.69	72.38	0.37	0.30
137119	100	3.005	35.93	0.28	1.1
A.P.I. Beta 35	210	26.22	125.3	0.41	0.0
137103[a]	210	4.079	39.68	0.35	1.26
137110	210	13.26	71.34	0.14	0.35
137120	210	3.008	36.32	0.47	1.2

[a] Results from nine different laboratories.

Using these experimental results, the averages of the existing conversion values were altered where necessary to conform with the experimental values. The corrected conversion values are given in Table I.

The Saybolt Universal viscosity values at 210 F. are higher than those at 100 F., for a given kinematic viscosity value, due principally to the fact that the oil volume is measured after cooling appreciably below the temperature of test. Since the coolinis is greater at 210 F. it is obvious that the volume of oil flowing through the tube at the temperature is larger. In the kinematic equipment the volume is measured at thg test temperature.

It is believed that conversions by means of the data shown in Table I are reproducible within at least 0.5 per cent between 36 and 1000 sec., Saybolt Universal. Experimental work will be continued in order to increase the accuracy of the conversion table and to extend the range of viscosity values covered.

APPENDIX IV

DEVELOPMENT OF COLOR STANDARDS FOR THE A.S.T.M. UNION COLORIMETER

The specifications for the glass color standards of the A.S.T.M. Union Colorimeter in the Tentative Method of Test for Color of Lubricating Oils by Means of A.S.T.M. Union Colorimeter (D 155 – 34 T)[1] and Tentative Method of Test for Color of Petrolatum by Means of A.S.T.M. Union Colorimeter (D 218 – 34 T)[1] are expressed as "Lovibond Analysis."

As a result of complaints that glass color standards varied appreciably, an attempt was made in 1932 to determine if The Tintometer, Ltd., was able to supply glass standards of uniformly acceptable quality. As a result of the examination of a set of glass standards which Tintometer supplied on the basis of matching the original master standards, it was decided that the present color specifications were inadequate to assure a supply of entirely acceptable glass standards.

The original glass color standards were forwarded to the National Bureau of Standards for the determination of their spectral transmissions. These data were used for the calculation of the trilinear coordinates, r, g, and b.[2]

American manufacturers of precision glass were approached to determine if they could use the data obtained by the Bureau as a basis for undertaking the manufacture at a reasonable cost of color standards which would agree within acceptable limits. No American manufacturer was found who would undertake the investigation without reimbursement of the cost (estimated at $5,000 to $10,000) of the research.

In 1933, the American representatives (Fish-Schurman Corp.) of the Jena Glass Works expressed a willingness to cooperate in the solution of this problem.

The National Bureau of Standards' report on the spectral transmission of the original Union Colorimeter standards and the calculations of trilinear coordinates r, g, and b, were forwarded to the Fish-Schurman Corp. with the request that the glasses be duplicated as nearly as possible. A complete set of glasses, designated J_1, was received from Jena and was forwarded to the Bureau for colorimetric analysis. Upon receiving the report from the Bureau, coordinates r, g, and b were calculated from the data.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, pp. 885, 890 (1934); also 1936 Book of A.S.T.M. Tentative Standards, pp. 606, 611.

[2] Report of Optical Society of America, Committee on Colorimetry (1920–21), L. T. Trolan, chairman, *Journal*, Optical Soc. America, Vol. 6, pp. 527–596 (1922); also Raymond Davis and J. S. Gibson, "Filters for Reproduction of Sunlight and Daylight and the Determination of Color Temperature," National Bureau of Standards *Miscellaneous Publication No. 114*.

The glasses were also compared visually with the original Union Colorimeter standards. This procedure made possible some conception of the relationship between the differences in quantitative colorimetric figures and differences in the visual appearances of the glasses.

The Bureau of Standards analysis of the Jena glasses and the calculations were returned to the Jena Glass Works with the information that five of the glasses would not be acceptable duplicates. Jena then supplied five replacements, designated J_2, for the glasses in question. These glasses were forwarded to the Bureau for analysis and the values r, g, and b were calculated from the Bureau data. At this stage of the work it was believed to be desirable to express the colorimetric values according to the system of calculations devised by Deane B. Judd of the Bureau of Standards.[1]

Therefore, the transmission data of both the J_1 and J_2 glasses were recalculated to determine the trilinear coordinates x, y, and z, using the I.C.I. Excitation Data and the Standard Illuminant "C." These figures were then submitted to Dr. I. H. Godlove of the Inter-Society Color Council, with the request that he review them and recommend the tolerances to be allowed.

Doctor Godlove suggested that the trilinear coordinates r, g, and b, be calculated and plotted on the Maxwell triangle of equal chromaticity scales.[2] With the intersections of these coordinates as centers, it will then be possible to draw a circle for each intersection of such a radius that all points within the circle represent color glasses the difference between which is not perceptible to the eye.

The suggestions of Dr. Godlove were followed and after plotting the values for all standard glasses, series J_1 and J_2, it was found that a radius of 0.006 units on the triangle enclosed all glasses which had been deemed acceptable by visual comparison and excluded those which had been found to be unsatisfactory. A careful study of the article by Judd[2] reveals that apparently the least perceptible difference in chromaticity is equal to 0.012 units on this Maxwell triangle. Therefore, this circle of 0.006 units radius is the locus of all glasses which would be just perceptibly different from each other but would not be perceptibly different from the standard.

There remained three Jena glasses which did not fall within the above requirements and which were questioned as a result of visual examination. Glass No. $3\frac{1}{2}$, being one of these, was replaced by Jena by two glasses $3\frac{1}{2}J_3$ and $3\frac{1}{2}J_4$, at least one of which Jena believed would be acceptable. After the necessary calculations had been made, it was found that $3\frac{1}{2}J_4$ fell well within the specifications but that $3\frac{1}{2}J_3$ failed to comply with the specifications.

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[1] Deane B. Judd, "The 1931 I. C. I. Standard Observer and Coordinate System for Colorimetry," *Journal*, Optical Soc. America, Vol. 23, p. 359 (1933).

[2] Deane B. Judd, "A Maxwell Triangle Yielding Uniform Chromaticity Scales," *Journal*, Optical Soc. America, Vol. 25, p. 24 (1935).

By visual comparison it has been found that a difference of 10 per cent in transmission (t_w) is perceptible in the A.S.T.M. Union colorimeter.

The development of the proposed limits for standard color glasses will show that the increments between the master standards, for transmission, trilinear coordinates, etc., are not uniform. This result is to be expected when optical equipment originally developed in a purely empirical manner is subjected to careful analysis by methods not originally available. It was felt that the proposed standard values for these glasses should be considered only from the viewpoint that their adoption will permit the reproduction of the original standards at any time by any competent glass maker and will insure uniformity. In view of the long established practice of determining colors by these methods, the question of whether new standards should be set up on a basis more scientifically sound, with regular variations between successive color values, is not at issue.

TABLE I.—SUGGESTED GLASS COLOR STANDARDS OF A.S.T.M. UNION COLORIMETER.

A.S.T.M. (N.P.A.) Color Numbers	Transmission Calculated from 1931 Excitation Data and Standard Illuminant "C"		Trilinear Coordinates to be Plotted on the Maxwell Triangle of Equal Chromaticity Scales			Radius of Circle on Maxwell Triangle of Equal Chromaticity Scales, with Intersection of r, g, and b Coordinates as Center Within Which Acceptable Glasses Must Fall
	t_w	Tolerance, per cent	r	g	b	
1	0.751	±10	0.462	0.476	0.062	0.006
1½	0.654	±10	0.491	0.477	0.032	0.006
2	0.443	±10	0.542	0.448	0.010	0.006
2½	0.365	±10	0.570	0.421	0.009	0.006
3	0.287	±10	0.600	0.393	0.008	0.006
3½	0.211	±10	0.636	0.360	0.005	0.006
4	0.096	±10	0.683	0.315	0.002	0.006
4½	0.065	±10	0.729	0.270	0.001	0.006
5	0.036	±10	0.790	0.210	.....	0.006
6	0.017	±10	0.841	0.159	.....	0.006
7	0.005	±10	0.896	0.104	.....	0.006
8	0.002	±10	0.940	0.060	.....	0.006

The incorporation of the suggested glass color standards shown in the accompanying Table I in the present A.S.T.M. Tentative Method of Test for Color of Lubricating Oils by Means of A.S.T.M. Union Colorimeter (D 155 – 34 T) and Tentative Method of Test for Color of Petrolatum by Means of A.S.T.M. Union Colorimeter (D 218 – 34 T) would be a distinct improvement in the methods. It is believed that these specifications would insure the obtaining of entirely acceptable glass standards.

No consideration has yet been given to the possible effect which the specifications would have upon the purchase price of the glasses.

Respectfully submitted on behalf of Subcommittee VI,

H. M. HANCOCK,
Chairman.

APPENDIX V

PROPOSED METHOD OF TEST FOR NEUTRALIZATION NUMBER OF PETROLEUM PRODUCTS AND LUBRICANTS (POTENTIOMETRIC METHOD)[1]

This is a **proposed method** and is published as information only. Comments are solicited and should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

1. *Scope.*—This method is applicable to the determination of the acidity of oils which are soluble in butyl or amyl alcohols. A suitable choice of organic solvent mixtures renders the method applicable to other oils. A mixture of 1 part of normal butyl alcohol to 1 part of benzene has been used successfully for certain oils that are difficult to dissolve.

2. *Outline of Method.*—A weighed sample of oil is dissolved in butyl alcohol and titrated with a standard solution of sodium butylate in butyl alcohol, using as an indicator the quinhydrone electrode with a saturated calomel half cell as a reference potential. The neutralization number is reported as milligrams of potassium hydroxide per gram of oil.

3. *Apparatus.*—The following apparatus will be required (see Supplements 1, 2, 3):

A. Potential Measuring System.—A thermionic titrometer system (see Fig. 1) or a Leeds & Northrup type K potentiometer and 2500-b galvanometer, or any other equivalent potentiometric system.

Thermionic Titrometer:

(*a*) The thermionic titrometer consists essentially of a vacuum tube circuit so arranged that any change in the potential of an indicator electrode, upon the addition of an increment of reagent, causes a proportional deflection of an indicating meter (Fig. 1).

(*b*) *Construction.*—The instrument may be constructed of the following or other equivalent apparatus:

Vacuum tube (Western Electric 257A or 231D) and socket (Western Electric 130A)
18,000 ohm potentiometer (General Radio type 371)
200 ohm and 50 ohm potentiometers (General Radio type 214)
2 Switch keys (Western Electric 272A)
Milliammeter, 0 to 100 milliamperes (Weston model 301)
Milliammeter, 0.01–0.1—1–10 milliamperes full scale (Rawson model 501)[a]
Phenol fiber panel and base
Heavy-duty batteries (Fig. 1)
Copper shield to cover tube and potentiometers.

[a] The resistance of the meter circuit must be adjusted, by means of series, as well as the shunt resistances, to have the same value for all four scale ranges.

The tube shall be mounted in a vertical position on the phenol fiber base. The variable resistors and switches shall be mounted on the vertical panel. All leads shall be soldered directly to their proper positions (see Fig. 1) without the use of binding posts, unless it is desired to make the instrument portable.

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[1] Under the standardization procedure of the Society, this proposed method is under the joint jurisdiction of the A.S.T.M. Committee D-2 on Petroleum Products and Lubricants and Committee D-9 on Electrical Insulating Materials.

(*c*) *Operation.*—In preparing the instrument for a titration the following procedure shall be followed: Turn S_1 from "Off" to "On" and see that S_2 is set at "Short" (Fig. 1). Adjust the shunt on the meter G and set R_1 and R_2 so that the meter needle is on the scale. By changing the shunt SH in steps and readjusting R_1 and R_2 the needle can be set on the most sensitive scale. With these circuit conditions the meter needle should be steady. In case erratic fluctuations occur when S_2 is at "Short" the trouble may usually be traced to faulty batteries. A bad contact can also cause this behavior, and if the batteries are in good condition the circuit must be traced to locate the source of the trouble. If the needle is steady on "Short" but erratic on "Read" the trouble is due to the electrode system. The E.M.F. leads should be checked, and the calomel half cell and the indicator electrode should be tested separately.

(*d*) *Precautions.*—There are certain important precautions to be exercised in the use of the titrometer. Whenever the electrodes are removed from the solution or disconnected from the instrument the meter shall first be short-circuited to prevent its being damaged. The meter should not be set on the most sensitive scale while the increment of reagent is being added. Old batteries and low-capacity batteries will cause drifts or erratic readings of the meter needle. The deflection should be approximately 10 divisions per millivolt. The sensitivity may be tested by impressing a potential on the grid using a simple potentiometer, setting the needle to zero, changing the potential 10 mv. and reading the meter.

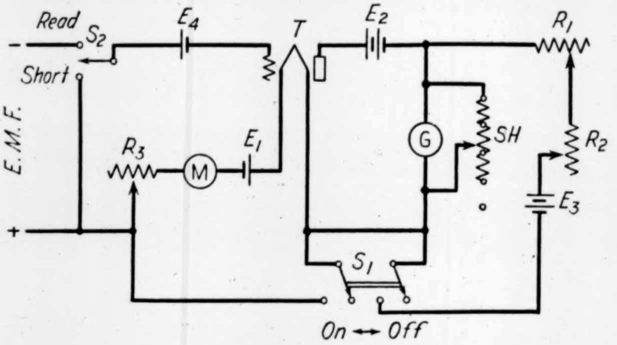

FIG. 1.—Thermionic Titrometer.

T = Vacuum tube (Western Electric 257A or 231D)
E_1 = 4 v. Lead storage battery (at least 25 amp-hr. capacity)
E_2 = $112\frac{1}{2}$ v.
E_3 = $22\frac{1}{2}$ v.
E_4 = 3 v.
S_1, S_2 = Switch keys (Western Electric 272A)
R_1 = 18,000 ohms
R_2 = 200 ohms
R_3 = 50 ohms
G = Milliammeter (Rawson model 501)
M = Milliammeter (Weston model 301)
Heavy-duty batteries throughout

B. Titration Cell.

C. Electrode System (see Fig. 2):

(*a*) *Reference Electrode.*—The reference electrode shall be a saturated calomel half cell (see Supplement 1) making contact with the solution by means of an agar bridge. The agar solution shall be made by dissolving approximately 20 g. of potassium chloride and 1.2 g. of agar in 100 ml. of hot water. A tube, drawn out to a capillary at one end, shall be filled half full with the warm agar solution. The tube shall then be completely filled with saturated potassium chloride solution and connected to the calomel half cell. The connecting bridge shall be thoroughly flushed out with saturated potassium chloride whenever the agar bridge is changed.

(*b*) ***Indicator Electrode.***—The indicator electrode shall consist of a bright platinum wire dipping into the solution to be titrated, to which about 50 mg. of finely pulverized quinhydrone has been added. The platinum wire shall be cleaned after use and just before use by washing off in clean ethyl alcohol and then heating to redness in the oxidizing tip of a bunsen flame, care being taken to shield the agar bridge from the flame with a beaker. Both electrodes should be immersed in butyl alcohol when not in use.

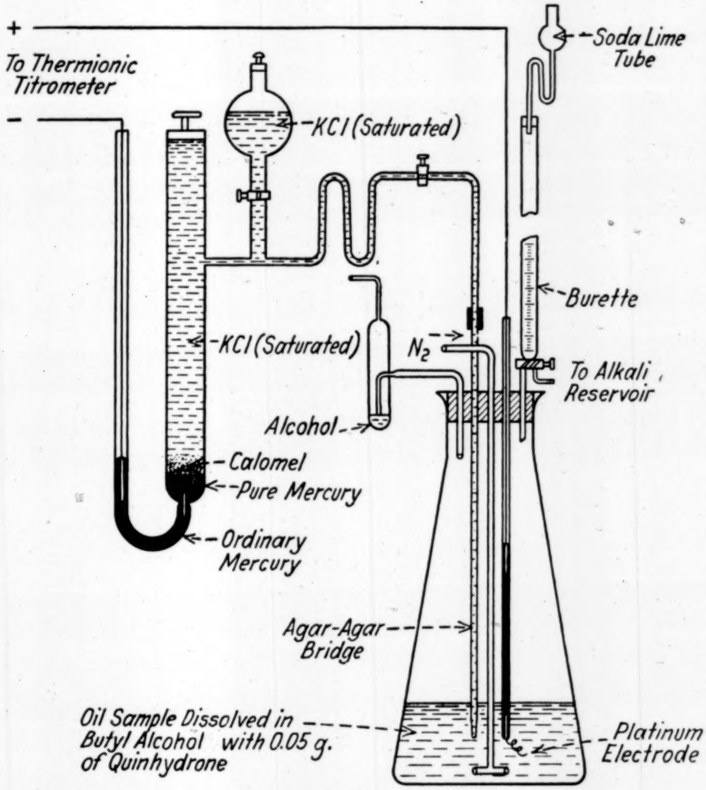
+
To Thermionic Titrometer
–
KCl (Saturated)
Soda Lime Tube
Burette
KCl (Saturated)
N_2
To Alkali Reservoir
Alcohol
Calomel
Pure Mercury
Ordinary Mercury
Agar-Agar Bridge
Oil Sample Dissolved in Butyl Alcohol with 0.05 g. of Quinhydrone
Platinum Electrode

FIG. 2.—Assembly of Apparatus Using Thermionic Titrometer.

D. Alkali Reservoir, Purifying Train, and Pipe Line:

The purifying train shall consist of two pyrogallol towers for removing oxygen, a calcium chloride tower for removing water vapor, and a soda lime tower for removing carbon dioxide from the air that replaces the reagent as the latter is removed from the reservoir. They shall be placed in the order mentioned as the reservoir is approached. The pyrogallol solution shall be prepared by dissolving 5 g. of pyrogallol in 15 ml. of water and adding 120 g. of potassium hydroxide dissolved in 80 ml. of water. A double flask or bulb mercury trap must be provided to protect the pyrogallol from diffusion of oxygen from the atmosphere. As an alternative to the use of the purifying train, the inlet may be kept permanently connected to a tank of compressed hydrogen, using a gentle pressure from the tank to fill the burette.

*E. **Burette.***—Two-way burette (10 ml. capacity).

*F. **Nitrogen.***—Tank of compressed nitrogen.

4. *Reagents:*

A. Materials Required.— The following materials will be required:

(*a*) *Solvent - Normal Butyl Alcohol.*—Purified as directed below.

(*b*) *Quinhydrone.*[a]

(*c*) *Lithium Chloride Anhydrous.*[a]—For Saturated Solution in Normal Butyl Alcohol, prepared as directed below.

(*d*) *Sodium Butylate.*—Solution prepared as directed below.

(*e*) *Agar-Agar.*

(*f*) *Pyrogallol.*

(*g*) *Soda Lime.*

(*h*) *Potassium hydroxide.*[a]

(*i*) *Calcium Chloride.*[a]

(*j*) *Barium Oxide.*[a]

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[a] Merck's Reagent Grade or equivalent.

B. Purification and Preparation for Use.—The reagents shall be purified and prepared for use as follows:

(*a*) *Normal Butyl Alcohol: Purification.*—To 1 liter of normal butyl alcohol add 100 g. of barium oxide, shake, and allow the solution to stand overnight, then vacuum distill, collecting the distillate in a lightproof bottle (Pyrex or equivalent heat-resisting glass is necessary for this purpose) discarding the first and last quarters of distillate.

(*b*) *Lithium Chloride Solution: Preparation.*—Prepare a saturated solution of lithium chloride by heating a portion of the pure normal butyl alcohol solvent in contact with an excess of the salt in a reflux apparatus. Protect the reflux train from the atmosphere by a purifying train as described above in Section 3 *D*. The heating shall be continued from 2 to 4 hr.

(*c*) *Sodium Butylate* (0.05 *N* Solution in Normal Butyl Alcohol, after purification of butyl alcohol as described above).—Dissolve 0.5 g. of sodium in 0.5 liters of the purified alcohol. Before adding the sodium, saturate the solution with hydrogen or nitrogen to displace carbon dioxide. Connect the syphon exit of the dark bottle (mounted in an elevated position) to the pipe line leading to the burette. Connect the entrance tube to the purifying train described in Section 3 *D*. Start the flow of alkali by a gentle pressure of nitrogen or hydrogen applied at the entrance of the train, after which it will flow by gravity. It is essential that the complete reservoir system, including reservoir and pipe line, be made lightproof with black lacquer.

5. *Test Procedure by Thermionic Titrometer.*—The test shall be made in accordance with the following procedure:

(*a*) Dissolve approximately 50 mg. of quinhydrone in 100 ml. of butyl alcohol (see Note), and add this to a weighed sample of approximately 10 g. of the oil to be tested contained in a 250-ml. Erlenmeyer flask. Add 5 ml. of saturated lithium chloride solution, agitate the flask and place it in position (Fig. 2). Bubble a fairly rapid stream of nitrogen through the solution for 10 min. before starting the titration. Meanwhile, connect the titrometer to the electrodes and adjust it for the titration as described in Section 3*A* (*c*).

(*b*) In titrating, adjust the needle to zero on the most sensitive scale, then change to a less sensitive scale, and add exactly 0.5 ml. of alkali. Record the equilibrium deflection and readjust the needle to zero. Add a second 0.5-ml. increment, recording the deflection as before. Proceed in this manner until a maximum deflection has occurred. This will locate the approximate position of the end point. Repeat the titration using approximately the same sized sample, first running in alkali until within 0.5 ml. of the maximum deflection found before, then adding increments of approximately 0.1 ml. recording deflections and setting the needle to zero each time as in the first titration. It is essential that the increments be of *equal size*, so it is best to add the increments *dropwise;* for example, if the burette delivers 40 drops per milliliter, add increments of 4 drops each. A little practice and calculation will be necessary in determining the exact number of drops to add as the standard increment. Carry the titration well beyond the maximum, as the shape of the curve on the alkaline side is important in determining the exact end point. Plot $\Delta E/\Delta$ ml. values as ordinates against milliliters, as abscissas. The maximum corresponds to the end point.

(*c*) Standardize the alkali in exactly the same manner as described in Paragraph (*b*), except that 100 mg. of the benzoic acid standard (No. 39*e*) of the National Bureau of Standards shall be used in place of the oil sample. It is necessary to standardize the alkali frequently when it is fresh, but after the second week, one or two standardizations a week will be sufficient. Titrate a blank exactly like a sample except that no oil or acid should be added. In general, the blank will remain constant as long as the supply of reagents remains unchanged, but it is well to titrate a new blank each time the alkali is standardized.

NOTE.—In case the oil is difficult to dissolve in butyl alcohol it is advantageous to use a solvent mixture instead of the pure alcohol. Recommended mixtures are benzene-butyl alcohol (1:1), dioxane-butyl alcohol (1:1), or anisol-butyl alcohol (1:1). A higher proportion of benzene or dioxane tends to cause a prohibitively high cell resistance.

6. *Test Procedure by Potentiometer System.*—In case a thermionic titrometer is not available, the test procedure shall be carried out as recommended in Section 5, with the following modifications:

(*a*) Use 10 ml. of lithium chloride solution instead of 5 ml.

(*b*) Use a potentiometer (Section 3 *A*) with a 2500-b galvanometer instead of the titrometer.

(*c*) The point of inflection in the voltage-volume curve may be taken as the end point. Since the maximum on the differential curve can be located with greater precision, however, it is recommended that the increments be of uniform size near the end point, as in Section 5 (*b*), and that the differential curve be plotted.

7. *Calculations.*—The neutralization number of the oil shall be calculated from the following formulas:

Standardization of Alkali:

$$\begin{array}{l}\text{Milligrams of KOH}\\ \text{per milliliter of alkali reagent}\end{array} = \frac{\text{Wt. benzoic acid} \times 56.1 \times 1000}{122.05 \times (\text{milliliters of alkali} - \text{correction for blank})}$$

Neutralization Number (*Acidity*):

$$\begin{array}{l}\text{Milligrams of KOH}\\ \text{per gram of sample}\end{array} = \frac{\begin{array}{c}\text{Milligrams of KOH per milliliter} \times (\text{milliliters of alkali} -\\ \text{correction for blank})\end{array}}{\text{Wt. of sample}}$$

SUPPLEMENTS

These following three supplements describe methods and work that are still in progress in the laboratories of the members of the committee and are described herein for the purpose of giving other laboratories an opportunity to try them out and compare their merits. It is requested that laboratories carrying out such work should communicate their data and comments to the Joint Committee addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Supplement 1. Preparation of Calomel Electrodes

Calomel electrodes may be represented in general by the illustration shown in Fig. A. A platinum wire, sealed in at *S*, connects specially purified mercury for the electrode with ordinary mercury, which is used merely for convenience in making the external connections.

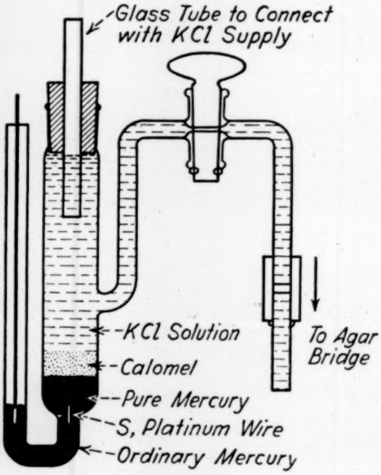
Glass Tube to Connect with KCl Supply
KCl Solution
Calomel
Pure Mercury
S, Platinum Wire
Ordinary Mercury
To Agar Bridge

FIG. A.—Calomel Electrodes.

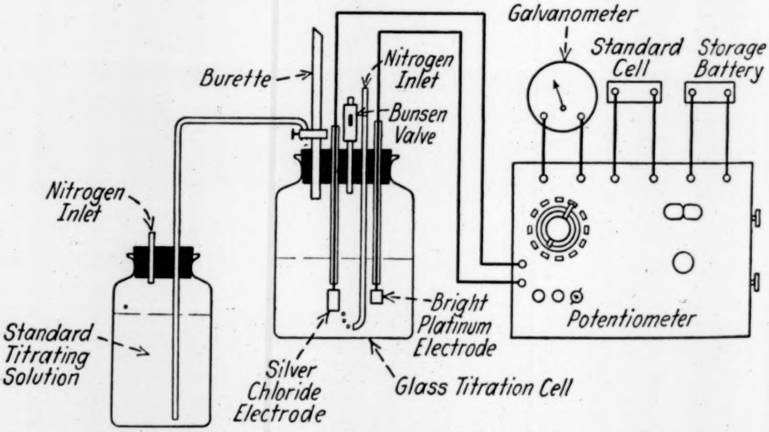
Galvanometer
Standard Cell
Storage Battery
Burette
Nitrogen Inlet
Bunsen Valve
Nitrogen Inlet
Standard Titrating Solution
Bright Platinum Electrode
Potentiometer
Silver Chloride Electrode
Glass Titration Cell

FIG. B.—Electrometric Titration Apparatus Using Silver Chloride Electrode.

In making up calomel electrodes, the important points are cleanliness and the use of the purest chemicals. Unless a source of specially purified chemicals is available, it is recommended that complete electrode with properly purified chemicals be purchased.

Three types of calomel electrodes are used, differing only in the strength of the potassium chloride solution. The solution strengths are tenth-normal, normal, and saturated. With this exception, all the cells are the same, so that the following instructions will serve for all three types.

Clean the glass vessel thoroughly, rinse it with distilled water, dry, and pour in specially purified mercury until the platinum wire, *S*, is covered. Cover the mercury with a layer of specially prepared calomel. Fill the vessel with the proper potassium chloride solution, which has been saturated with specially purified calomel. The potassium chloride need not be specially prepared, but should be the purest obtainable. Close the vessel by inserting the stopper and closing the stopcock, *and then shake the container* (Note). After settling, the electrode is ready for use. Make sure the side arm is filled with liquid, free from bubbles.

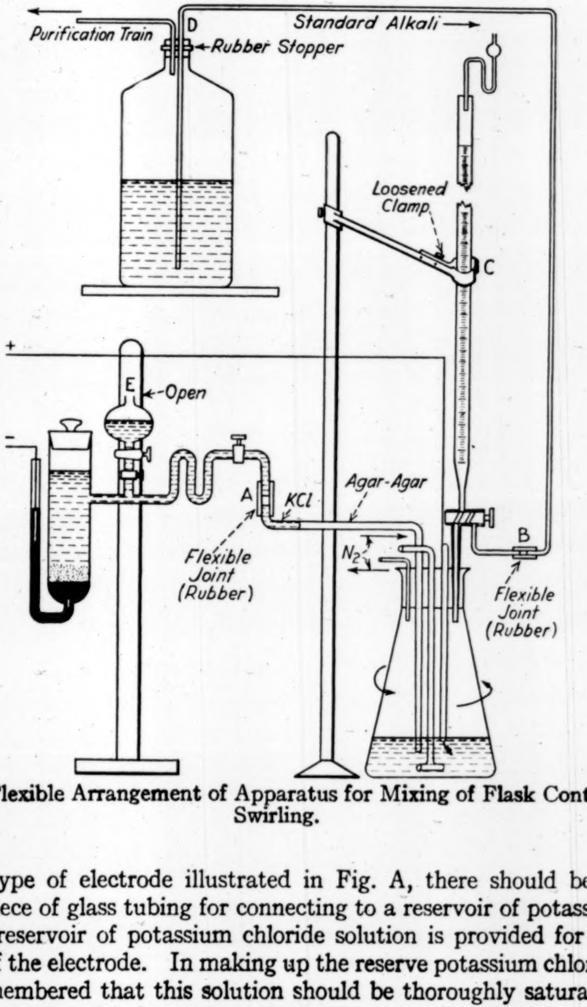

FIG. C.—Flexible Arrangement of Apparatus for Mixing of Flask Contents by Swirling.

With the type of electrode illustrated in Fig. A, there should be provided a stopper and a piece of glass tubing for connecting to a reservoir of potassium chloride solution. The reservoir of potassium chloride solution is provided for flushing out the side outlet of the electrode. In making up the reserve potassium chloride solution, it should be remembered that this solution should be thoroughly saturated with the specially prepared calomel before it is ready for use.

Preparation of Potassium Chloride Solution.—The following information for making up potassium chloride solutions is offered, based upon volume normal solutions. For work of the highest accuracy, fused KCl should be used:

Tenth-Normal Solution.—7.45 g. of potassium chloride per liter of solution.

Normal Solution.—74.56 g. of potassium chloride per liter of solution.

Saturated Solution.—Dissolve potassium chloride in distilled water until an excess is apparent.

For convenience in making up these solutions, a liter flask should be provided. Place the potassium chloride in the flask first, then add the distilled water to within a few milliliters of the liter mark. When all the KCl is dissolved and the solution is at 20 C., fill the flask to the liter mark with distilled water.

NOTE.—One cooperating laboratory has found that the best results are obtained by adding the mercury to cover the sealing-in wire, then the layer of calomel and finally the potassium chloride solution but *without* shaking as directed in the instructions. When the cell was shaken it was found that much greater drift took place when running titrations.

Supplement 2. Silver Chloride Electrode

One laboratory has found that a more stable and more easily prepared electrode substitute for the calomel half cell and agar-agar bridge may be prepared by dipping a piece of sheet silver in fused silver chloride. The arrangement of the apparatus is shown in Fig. B.

This type of electrode appears to need no washing, shows very little tendency to drift, and does not appear to darken appreciably due to exposure to light. The details of the preparation of the dipped electrode are as follows: Prepare the silver chloride by precipitation from a silver nitrate solution with hydrochloric acid, then purify the silver chloride by boiling with water three or four times, the water being decanted each time. After separating the silver chloride by filtration, place it into a porcelain crucible, and melt. Dip a strip of sheet silver, 10 by 50 mm. (previously fastened to a small piece of platinum wire fused into a glass tube) into the melted chloride, remove immediately, and allow to cool. The electrode is then ready for use.

Supplement 3. Method of Flexibly Supporting Test Cell

One of the cooperating laboratories reports that the drift of potential after each addition of the alkali can be markedly reduced, or even completely eliminated by supplementing the agitation produced by the bubbling of nitrogen through the test cell by a flexible mounting which will allow the operator to twirl the test cell, by hand, after each such addition. The method of flexibly supporting the cell for this purpose is illustrated in Fig. C. At *A*, the agar-agar bridge is connected to the calomel half-cell by means of a tight-fitting piece of rubber tubing which makes a flexible connection. Insurance against formation of air bubbles at this junction is obtained by leaving the KCl reservoir at *E* open to atmospheric pressure. This arrangement also prevents the agar-agar jelly from being forced through the bridge when pressure is applied at *A*.

At *B* another tight-fitting piece of rubber tubing serves as a flexible connection between the standard solution reservoir and the dispensing burette. During use, the burette is supported by the rubber stopper in the test flask and is held in place by a loosened clamp *C*, thus allowing flexible movement during the swirling operation.

APPENDIX VI

SUGGESTED UNIFORM AUTOMOTIVE ENGINE LUBRICATION RECOMMENDATIONS

To obtain best performance it is essential to use the correct grade (S.A.E. No.) of motor oil (as specified by the car manufacturers) in the engine crankcase. This should be of a lower S.A.E. number in cold than in warm weather to provide easier starting in winter and economical consumption in summer. The motor oil should be changed in accordance with the general temperature variations rather than according to seasons. In some localities variations in temperature are so extreme that several grades may be required during the course of a year. It is also essential to add oil, as required, to maintain the correct oil level.

To insure continuation of best performance, low maintenance costs, and long motor life, it is necessary to change the crankcase oil when it becomes contaminated. Driving over dusty roads or through dust storms introduces abrasive material in the crankcase. If this is not removed immediately by draining the crankcase, harmful engine wear may result.

In warm weather, hard driving causes chemical changes in the oil. Accumulation of the products of these changes is undesirable and may prove harmful to the engine.

In winter, particularly during intermittent driving, water accumulates in the crankcase from condensation of moisture produced by the burning of the fuel. Water may freeze and interfere with proper oil circulation. It also promotes rusting and causes clogging of oil screens and passages. While on long continuous drives this water may be removed by the crankcase ventilator, draining is a safer procedure. When light oils are used for easy starting, hard driving may thicken the oil and cause starting trouble during the next cold spell.

Obviously, the time between changes of the crankcase oil depends entirely upon the driving conditions. In considering the above factors as to when to change the oil it should be kept in mind that good lubrication is cheap insurance against high maintenance costs.

APPENDIX VII

DIESEL-FUEL-OIL CLASSIFICATION

Manufacturers and users of Diesel engines, as well as petroleum refiners and distributors, have long felt the need for some classification differentiating types of fuel oils suitable for Diesel engines. The classification shown in Table I, covering five grades of oil, was developed by Technical Committee C on Fuel Oils (Including Diesel Fuel) of Committee D-2 on Petroleum Products and Lubricants in an attempt to supply this need. This classification was first presented in June, 1934, and has been revised as a result of suggestions since received.

TABLE I.—DIESEL-FUEL-OIL CLASSIFICATION.

Grade of Diesel Fuel	Flash Point, deg. Fahr.	Water and Sediment, per cent by Volume	Viscosity, seconds			Carbon Residue, per cent by weight	Ash, per cent by weight	Pour Point, deg. Fahr.	Sulfur, per cent by weight	Ignition Quality
			Saybolt Universal (at 100 F.)		Saybolt Furol (at 122 F.)					
	Min.[a]	Max.	Min.[b]	Max.	Max.	Max.	Max.	Max.[c]		
No. 1-D	115 or legal	0.05	35	50	...	0.2	0.02	35	[d]	[e]
No. 3-D	150	0.1	35	70	...	0.5	0.02	35	[d]	[e]
No. 4-D	150	0.6	..	250	...	3.0	0.04	35	[d]	[e]
No. 5-D	150	1.0	..	...	100	6.0	0.08	..	[d]	..
No. 6-D	Limits for No. 6-D fuel are the same as for No. 6 oil in the Tentative Specifications for Fuel Oils (A.S.T.M. Designation: D 396 - 34 T) of the American Society for Testing Materials,[1] unless modified by special negotiations between buyer and seller.									

[a] Minimum flash point, as stated or as required by local fire regulations, Fire Underwriters or state laws.

[b] For viscosities below 35 sec. at 100 F. Saybolt Universal, other methods than that by the Saybolt Universal viscosimeter at 100 F. may be used and the results converted.

[c] Lower pour points may be specified whenever required by local temperature conditions to facilitate storage and use, although the minimum viscosity specified for Oils Nos. 1-D and 3-D must be waived whenever it is necessary to require a pour point of less than 10 F.

[d] So far as known, sulfur content need not be considered as regards combustion characteristics. However, when sulfur content is of consequence—as, for instance, in fuel for engines in intermittent service—the following limits are suggested:

Fuel No. 1-D........ 1.5 per cent max.
Fuel No. 3-D........ 1.5 per cent max.
Fuel No. 4-D........ 2.0 per cent max.
Fuel No. 5-D........ 2.0 per cent max.

[e] See Table II and discussion in Paragraph (*h*) of the text.

TABLE II.—IGNITION QUALITY.[a]

	OIL GRADES		
	No. 1-D	No. 3-D	No. 4-D
Cetane number by the delay method, min.	45	35	30
Diesel index number, min	45	30	20
Viscosity-gravity number, max	0.86	0.89	0.91
Boiling-point - gravity number, max	188	195	200

[a] The values in Table II are equivalent within the limits of error of the test methods used. As the correlations between indexes and between any index and engine operation in the field are not completely established as yet, these values should be used in an approximate way only.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, p. 882 (1934); also 1936 Book of A.S.T.M. Tentative Standards, p. 603.

It is not the intention of the committee that this classification should be used as purchase specifications; but rather that fuels purchased be correlated according to the proposed classification in order to determine its usefulness. A series of Diesel-fuel-oil specifications should evolve as a result of this program. Criticism and comment should be forwarded to Mr. R. P. Anderson, Secretary of Committee D-2 on Petroleum Products and Lubricants, 50 West 50th Street, New York, N. Y.

METHODS OF TESTING

The properties listed in this classification are determined in accordance with the following methods of testing:

(*a*) *Flash Point.*—In absence of legal or local requirements, the minimum flash point shall be determined in accordance with the Standard Method of Test for Flash Point by Means of the Pensky-Martens Closed Tester (A.S.T.M. Designation: D 93) of the American Society for Testing Materials.[1]

(*b*) *Water and Sediment.*—Standard Method of Test for Water and Sediment in Petroleum Products, by Means of Centrifuge (A.S.T.M. Designation: D 96) of the American Society for Testing Materials.[2]

(*c*) *Viscosity.*—Standard Method of Test for Viscosity by Means of the Saybolt Viscosimeter (A.S.T.M. Designation: D 88) of the American Society for Testing Materials.[3]

(*d*) *Carbon Residue.*—Standard Method of Test for Carbon Residue of Petroleum Products (Conradson Carbon Residue) (A.S.T.M. Designation: D 189) of the American Society for Testing Materials.[4]

(*e*) *Ash.*—Place 10 g. of the fuel oil in a weighed uncovered platinum crucible of a capacity not greater than 100 ml. and heat gently with a Bunsen burner until the oil fires and continues to burn when the flame of the burner is applied to the surface of the oil. Allow the oil to burn without further application of heat. The oil will continue to burn until practically all of it has disappeared. The time required will be about 50 min. Then place the platinum crucible in a gas or electric furnace and heat to a bright red heat until all carbon is consumed. Cool, weigh and report the residue as ash expressed as a percentage of the original 10-g. sample.

(*f*) *Pour Point.*—Standard Method of Test for Cloud and Pour Points (A.S.T.M. Designation: D 97) of the American Society for Testing Materials.[5]

(*g*) *Sulfur.*—Standard Method of Test for Sulfur in Petroleum Oils by Bomb Method (A.S.T.M. Designation: D 129) of the American Society for Testing Materials.[6]

(*h*) *Ignition Quality.*—According to present opinion, combustion knock in a fuel-oil-injection engine is caused by the accumulation of fuel in its cylinders prior to ignition. Even under conditions that insure ignition, the fuel may not ignite instantaneously but only after a definite delay. The longer this delay, the more fuel accumulates in the cylinders, which then burns unevenly, finally causing audible knock. If the delay is extreme, the engine will fail to operate with the fuel. It is significant that every factor which tends to aggravate knocking in a spark-ignition gasoline engine tends to suppress it in Diesel engines. Fuels of paraffin base consisting chiefly of saturated straight-chain hydrocarbons give the smoothest combustion in general, while naphthenes and aromatics burn roughly at low compression ratios. It is known that highly cracked products give trouble and also that the amount of trouble is increased as the speed of the engine is increased. Turbulence in the charge mixture reduces the delay period and turbulence is a controlling factor in engine speed. It is now generally agreed that ignition quality is one of the most important characteristics of Diesel fuels.

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 897.
[2] *Ibid.*, p. 1001.
[3] *Ibid.*, p. 982.
[4] *Ibid.*, p. 849.
[5] *Ibid.*, p. 853.
[6] *Ibid.*, p. 974.

The committee realizes the impossibility of reducing all types and designs of engines to a common rating for fuel-burning characteristics. Engine factors, such as combustion-chamber design, turbulence, spray characteristics, compression ratio, injection timing, and engine speed, vary greatly in different engine makes. Tests of ignitibility on various types of engines have no theoretical significance but have provided practical data for the types and sizes of engines on which the tests were performed. Fuel characteristics are based on a study of field-engine performance correlated with laboratory ratings of various test fuels. Ignitibility, one of the most important characteristics from the standpoint of satisfactory engine operation, has been expressed by such indices of performance as cetane number, Diesel index number, viscosity-gravity number, and boiling-point-gravity number.

CETANE NUMBER.—Cetene number was first proposed by Boerlage and Broeze of the Bataafsche Petroleum Maatschappij[1] and is the percentage of cetene in a blend of cetene and alphamethylnaphthalene which has the same ignition quality (measured in a specified engine under a definite set of engine conditions) as the fuel under test. It has been found that more reliable results may be possible when using cetane rather than cetene. For this reason, this classification substitutes the cetane number, which is determined and expressed in the same manner as the cetene number, namely, as the percentage of cetane in a blend of cetane and alphamethylnaphthalene.

DIESEL INDEX NUMBER.—Diesel Index number is calculated from aniline point and A.P.I. gravity by the following formula:

$$\text{Diesel Index Number} = \frac{(\text{A.P.I. gravity at 60 F.}) \times (\text{aniline point in deg. Fahr.})}{100}$$

Aniline Point is the lowest temperature at which equal parts by volume of freshly distilled aniline and the test sample of oil are completely miscible. It is determined by heating such a mixture in a jacketed test tube to a clear solution and noting the temperature at which turbidity appears as the mixture is cooled.

For A.P.I. Gravity see the Standard Method of Test for Gravity of Petroleum and Petroleum Products by Means of the Hydrometer (A.S.T.M. Designation: D 287) of the American Society for Testing Materials.[2]

VISCOSITY - GRAVITY NUMBER.—Viscosity - Gravity Number was first proposed by Hill and Coats in 1928 and a modification was later advanced by Moore and Kaye in 1934.[3] The number is determined by the following equation:

$$G = 1.082\,A - 0.0887 + (0.776 - 0.72A) \times \log\log\,(KV - 4)$$

where G = specific gravity at 60 F.
A = viscosity - gravity constant
KV = kinematic viscosity in millistokes at 100 F.

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[1] Boerlage and Broeze, "Ignition Quality of Diesel Fuels as Expressed in Cetene Numbers," *Journal*, Soc. Automotive Engrs., July, 1932.

[2] 1936 Book of A.S.T.M. Standards, Part II, p. 918.

[3] Moore and Kaye, "Practical Evaluation of the Ignition Characteristics of Diesel Fuel Oils," *Oil and Gas Journal*, p. 108, November 15, 1934.

BOILING-POINT - GRAVITY NUMBER.—Boiling-Point - Gravity Number was first proposed by E. A. Jackson[1] in 1935. Generally speaking, the larger the number, the more naphthenic the oil, and the lower the number, the more paraffinic the oil. The number is determined by the following equation:

$$G = A + (68 - 0.703A) \log B.P.$$

where G = A.P.I. gravity in degrees
A = Boiling-point - gravity constant
$B.P.$ = 50 per cent boiling point on A.S.T.M. distillation curve in degrees Cent.

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[1] E. A. Jackson, "Boiling-Point-Gravity Constant is Index of Lubricating Oil Characteristics," *Oil and Gas Journal*, March 21, 1935.

REPORT OF COMMITTEE D-3

ON

GASEOUS FUELS

Early in 1934 the need for nationally accepted methods for sampling, measuring and analyzing gaseous fuels was recognized and a conference of interested industries called to consider plans for the development of such standards. Inasmuch as the major portion of interest in such procedures arose within the A.S.T.M., officials of that organization decided to accept sponsorship for the project and a meeting was called to consider this subject at the Wardman Park Hotel in Washington, D. C., on March 7, 1934. A wide representation of industries was present, and the final outcome of discussions that took place was the creation of a Study Committee which was instructed to report its findings to the same conference group at the annual meeting of the Society in Atlantic City on June 27 of the same year. At this meeting general recommendations of the Study Committee that a standing committee on gaseous fuels be established to standardize nomenclature, and methods of sampling and testing gaseous fuels, so far as they apply to purchases and sales, and the requirements of regulatory bodies, were approved and a Steering Committee was created under the leadership of A. C. Fieldner and instructed to select an appropriate committee and draw up preliminary plans. A meeting of this latter group was held at the American Gas Association Headquarters in New York City, on October 10, 1934. After very thorough consideration of the whole matter it was decided that national laboratory standards should be prepared for the purpose of determining the following items:

1. Sampling
2. Measuring
3. Calorific Value
4. Specific Gravity
5. Impurities
6. Water Vapor Content
7. Complete Analysis

The report of the Steering Committee was approved and the first meeting of the new committee, designated as Committee D-3 on Gaseous Fuels, was held during the 1935 annual meeting of the Society in Detroit, Mich., on June 26, 1935. At this meeting, committee officers and an Advisory Committee were elected, organization was completed, and tentative subcommittee personnel was selected. The total membership of 30 consisted of 11 producers, 9 consumers and 10 representing general and scientific interests.

Following a meeting of the Advisory Committee which was held at the American Gas Association's Testing Laboratories in Cleveland, Ohio, on September 30, 1935, a second meeting of Committee D-3 was held in Chicago, Ill., on October 14, 1935, during the American Gas Association's Annual Convention. At the latter meeting, selection of subcommittee personnel was completed, and tentative programs were considered in detail.

During the intervening period between the second meeting of the main committee and the third one, which was held during the Spring Meetings of A.S.T.M. Committees in Pittsburgh, Pa., March 2, organization of the various subcommittees was completed, preliminary programs for the guidance of subcommittees approved, and the whole program of developing methods and test standards inaugurated. A list of these subcommittees, together with their chairmen, objectives and scope, is given at the end of this report.

From the beginning it has been the committee's recommendation and understanding that its activities are to be limited to commercially available fuel gases combustible in air. This scope not only covers all of the various types of generally classified city gases but practically all of the so-called bottled gases as well. Although these activities are to be limited to laboratory procedures, there is no doubt that they will affect, indirectly at least, commercial practices employed in the measurement, determination of quality, and the sale of common types of fuel gases. As such, they should prove of great interest and benefit to industries distributing such products and particularly those portions of the American public now representing approximately half of the population of the entire United States utilizing gaseous fuels.

OBJECTIVES AND SCOPE OF SUBCOMMITTEES

SUBCOMMITTEE I ON COLLECTION OF GASEOUS FUEL SAMPLES. S. S. TOMKINS, Chairman.

Object.—The objective of this committee shall be the development and formulation of standard methods and procedures for obtaining, collecting, and storing true samples of gaseous fuels.

Scope.—The scope of this committee shall be substantially as follows:

First, development of a standard method of securing gaseous fuel samples under varying conditions of temperature and pressure.

Second, development of a standard method of collecting gaseous fuel, spot and continuous samples.

Third, development of a standard procedure for storing gaseous samples.

Fourth, formulation of a specification of location in respect to existing structures for obtaining a true fuel sample.

Special Consideration.—1. Definition of terms, such as: sample, sampling tube, collection tube, container, storing reservoirs and other related items.

2. Size of sample to be secured.

3. Method of collecting the desired sample. This will include the standardization of sampling tube and accessory apparatus.

4. Storage of sample. A recommended procedure and the type of reservoir to be employed in standard practice. If gas is stored under an appreciable pressure, consideration shall be given to the possible effect of this pressure on the stability of the fuel gas sample.

5. Rates of collecting samples to be specified.

SUBCOMMITTEE II ON MEASUREMENT OF GASEOUS FUEL SAMPLES. H. S. BEAN, Chairman.

Object.—The objective of this committee shall be the development and formulation of standard methods and procedures for measuring gaseous fuel samples.

Scope.—The scope of this committee shall be substantially as follows:

First, formulation of standards of temperature, pressure and humidity for the measurement of gaseous fuels.

Second, study of various methods of measuring gaseous fuels and the limitations of each.

Third, development of standard methods for calibrating gaseous measuring devices.

Fourth, study of variations from ideal gas laws and the necessary corrections.

Special Consideration.—1. Definitions of terms such as: standard cubic foot of gas, standard conditions and other related items.

2. Standard units of measurement.

3. Standardization of apparatus for measuring gaseous fuel samples.

4. Accuracy of various types of meters.

5. Standard method of calibrating measuring devices employed for gaseous fuels.

6. Selection of suitable tolerances and probable errors.

SUBCOMMITTEE III ON DETERMINATION OF CALORIFIC VALUE OF GASEOUS FUELS. R. B. HARPER, Chairman.

Object.—The objective of this committee shall be the development and formulation of standard methods and procedure for obtaining the true calorific value of fuel gases.

Scope.—The scope of this committee shall be substantially as follows:

First, selection of acceptable types of standard apparatus for the determination of calorific values of gaseous fuels.

Second, development of a standard method of procedure for obtaining the calorific value of gaseous fuels.

Third, evaluation and standardization of required corrections necessary for determination of the calorific value of gaseous fuels under varying conditions of temperature, pressure and humidity.

Fourth, correlation of data to enable the calorific value of gaseous fuels to be determined from exact chemical analysis of the fuel gas.

Special Consideration.—1. Definition of terms such as: gross heating value, net heating value, calorimeter heating value, B.t.u., calorimeter efficiency, standard conditions, and other related terms.

2. Establishment of standard methods of calibration of standard types of calorimeters.

3. Determination of frequency at which determinations should be made.
4. Selection of suitable tolerances and probable errors.

SUBCOMMITTEE IV ON DETERMINATION OF SPECIFIC GRAVITY AND DENSITY OF GASEOUS FUELS. CARL D. ULMER, Chairman.

Object.—The objective of this committee shall be the development and formulation of standard methods and procedures for determining the specific gravity and density of gaseous fuels.

Scope.—The scope of this committee shall be substantially as follows:

First, establishment of types of standard apparatus for the determination of the specific gravity and density of gaseous fuels.
Second, development of methods of procedure for obtaining the specific gravity and density of gaseous fuels.
Third, development of methods of calibrating the standard apparatus employed in obtaining specific gravity and density of gaseous fuels.
Fourth, evaluation and standardization of required computations and corrections necessary to the determination of specific gravity and density of gaseous fuels.
Fifth, correlation of data to enable the specific gravity and density to be determined from exact chemical analysis of the fuel gas.

Special Consideration.—1. Standardization of such terms as: specific gravity, density and other related terms.

2. Effect of humidity on the specific gravity and density of gaseous fuel.

3. Corrections necessary to reduce specific gravity and density of gaseous fuels to standard conditions.

4. Selection of suitable tolerances and probable errors.

SUBCOMMITTEE V ON DETERMINATION OF IMPURITIES OF GASEOUS FUELS. W. P. YANT, Chairman.

Object.—The objective of this committee shall be the development and formulation of standard methods and procedures for determinations of impurities in gaseous fuels.

Scope.—The scope of this committee shall be substantially as follows:

First, standardization of types of standard apparatus for the determination of the impurities in gaseous fuels.
Second, determination of standard methods for obtaining the impurities in gaseous fuels.
Third, determination of standard methods for calibrating the apparatus employed in obtaining the impurities in gaseous fuels.
Fourth, evaluation and standardization of corrections necessary to the determination of the impurities in gaseous fuels.

Special Consideration.—1. Definition of terms such as: impurities in gaseous fuels and other related items.

2. Selection of suitable tolerances and probable errors.

SUBCOMMITTEE VI ON DETERMINATION OF WATER VAPOR CONTENT OF GASEOUS FUELS. A. W. GAUGER, Chairman.

Object.—The objective of this committee shall be the development and formulation of standard methods and procedures for determining the true water vapor content of gaseous fuels.

Scope.—The scope of this committee shall be substantially as follows:

First, selection of various types of apparatus to be considered as standard
Second, development of standard methods of determining the water vapor content.
Third, development of standard methods of calibration of instruments and apparatus.

Special Consideration.—1. Definition of terms such as: relative humidity and absolute humidity.

2. Development of method of maintaining constant humidity of gaseous samples.
3. Establishment of suitable degree of humidity for analysis of gaseous samples.
4. Selection of suitable tolerances and probable errors.

SUBCOMMITTEE VII ON COMPLETE ANALYSIS OR CHEMICAL COMPOSITION OF GASEOUS FUELS. MARTIN SHEPHERD, Chairman.

Object.—The objective of this committee shall be the development and formulation of standard methods and procedures for obtaining complete analysis or chemical composition of gaseous fuels.

Scope.—The scope of this committee shall be substantially as follows:

First, selection of types of apparatus to be considered as standard.
Second, development of standard methods for obtaining analysis of gaseous fuels.
Third, selection of reagents to be considered as standard in gaseous fuel analysis.
Fourth, evaluation and standardization of calculation and corrections necessary in the analysis of gaseous fuels.

Special Consideration.—1. Definition of terms such as: gaseous fuel and various types of gaseous fuels, illuminants, slow combustion, explosion, complete analysis, fractional distillation, and other related terms.

2. Consideration should be given to a standard method for determining illuminants in a gaseous fuel.
3. Determination of the rate of absorption, rate of deterioration, efficiency and life of the various reagents employed in the analysis of gaseous fuels.
4. Cooperation with National Bureau of Standards in its project on fuel gas analysis.
5. Selection of suitable tolerances and probable errors.

The election of officers for the ensuing term of two years resulted in the re-election of the present incumbents.

This report has been submitted to letter ballot of the committee, which consists of 29 members; 25 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

A. C. FIELDNER,
Chairman.

R. M. CONNER,
Secretary.

R. B. HARPER,
Vice-Chairman.

REPORT OF COMMITTEE D-4

ON

ROAD AND PAVING MATERIALS

Committee D-4 on Road and Paving Materials, in an appendix to its 1935 annual report, presented eight proposed tentative methods of test for soils. These methods were subsequently approved[1] by letter ballot of the committee and were then referred to Committee E-10 on Standards with the recommendation that they be issued by the Society as tentative. At a meeting of Committee E-10 on August 22, 1935, these recommendations were accepted and the new methods, the titles and designations of which are as follows, have been published in the 1935 *Proceedings:*[2]

Tentative Methods of:

Surveying and Sampling Soils for Use in Place as Subgrades for Highways (D 420 - 35 T),
Preparing Soil Samples as Received from the Field for Mechanical Analysis and the Determination of the Subgrade Soil Constants (D 421 - 35 T),
Mechanical Analysis of Soils (D 422 - 35 T),
Test for Liquid Limit of Soils (D 423 - 35 T),
Test for Plastic Limit and Plasticity Index of Soils (D 424 - 35 T),
Test for Centrifuge Moisture Equivalent of Soils (D 425 - 35 T),
Test for Field Moisture Equivalent of Soils (D 426 - 35 T), and
Test for Shrinkage Factors of Soils (D 427 - 35 T).

On January 3, 1936, the Division of Simplified Practice of the U. S. Department of Commerce issued a "Proposed Simplified Practice Recommendation for Coarse Aggregates." This recommendation was referred to Committee D-4 and reviewed by its Subcommittee B-9 on Size of Aggregates. Upon the recommendation of this subcommittee, Committee D-4 has approved in substance and form the sizes of aggregates as submitted by the Division of Simplified Practice, in so far as they apply to highway construction, and has instructed its subcommittees concerned with specific sizes of aggregates for particular types of construction and methods of test to review the standard submitted and, if possible, to fit the proposed sizes to the specifications under their jurisdiction, or to offer criticisms of these sizes, if deemed desirable, for the revision of the simplified practice recommendation before its promulgation by the Division of Simplified Practice.

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[1] In submitting these methods to Committee E-10 on Standards, Committee D-4 reported the following results of the letter ballot vote of a total of 58 ballots returned from a committee membership of 92: Method D 427 - 35 T, affirmative 41, negative 1, ballots marked "not voting" 16; on each of the other tentative methods, affirmative 42, negative 0, ballots marked "not voting" 16.

[2] *Proceedings,* Am. Soc. Testing Mats., Vol. 35, Part I, pp. 940 to 982, inclusive (1935); also 1935 Book of A.S.T.M. Tentative Standards, pp. 876 to 913, inclusive.

Approval of this procedure was obtained by letter ballot with the following results: 72 members returned their ballots, of whom 48 have voted affirmatively, 0 negatively, and 13 marked their ballots "not voting."

Since the March meeting of Committee D-4, the Division of Simplified Practice has requested approval by the Society of its recent revision of Simplified Practice Recommendation R-4 on Asphalt. Although no letter ballot has been taken by Committee D-4 on this matter, the entire membership has been canvassed on this proposal with the result that at its meeting on July 2 it was voted that the proposed revision be approved as in the case of the Proposed Simplified Practice Recommendation for Coarse Aggregates.

RECOMMENDATIONS AFFECTING STANDARDS

I. Proposed Revision of Standard:

Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (*D 6 – 33*).[1]—In order to eliminate ambiguity in the ventilation requirements for the oven, the committee recommends the following revision in this method and, since the proposed revision does not affect the method itself, it is recommended that it be considered an editorial change and made immediately:

Section 2.—Change the fourth paragraph of this section to read as follows by the addition of the italicized words and the omission of those in brackets:

> [One round vent hole each shall either be placed in the top and bottom of the oven or one only near the top and one only near the bottom on each side of the oven.] *The oven shall be provided with vent holes placed as follows:* (*a*) *At the top; one in the top of the oven or one near the top of each of two opposite sides of the oven.* (*b*) *At the bottom; one in the bottom of the oven or one near the bottom of each of two opposite sides of the oven.* Each hole shall be not less than 1.27 cm. (0.5 in.) nor more than 1.60 cm. (0.63 in.) in diameter and [they] *each hole* shall [both] be left open during the operation of the oven.

II. Proposed Adoption of Tentative Standards as Standard:

Tentative Method of Test for Residue of Specified Penetration (*D 243-35 T*).[2]—Since the revision of this test in 1935, no criticisms have been received and the committee accordingly recommends that this method be approved for reference to letter ballot of the Society for adoption as standard.

Tentative Volume Correction Table for Asphaltic Products.—In its 1935 annual report, Committee D-4 joined with Committee D-8 on Bituminous Waterproofing and Roofing Materials in recommending that the tables designated as Group 0 and Group 1 in the Standard Abridged Volume

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 962.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 935 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 861.

Correction Table for Petroleum Oils (D 206 – 34)[1] be tentatively approved as a Volume Correction Table for Asphaltic Products. This recommendation was accepted by the Society but instead of issuing the tables for these groups as a separate tentative standard which would involve duplication in publication, a footnote indicating this tentative approval was added to the tables for Group 0 and Group 1 in Standard D 206 – 34. As these tables are now in common use by the producers and consumers of asphaltic products, Committee D-4 joins with Committee D-8 in recommending that their use for these products be formally approved by the Society as standard and that the present footnote be changed to read as follows:

> These tables for Group 0 and Group 1 have been adopted as standard by the Society as volume correction tables for asphaltic products on the joint recommendation of Committee D-4 on Road and Paving Materials and Committee D-8 on Bituminous Waterproofing and Roofing Materials.

Tentative Method of Test for Separation of Liquid Asphaltic Products (D 402 – 34 T).[2]—Since its publication as tentative this test has been widely used but trouble has been encountered in meeting the requirements for length of condenser tube in connection with standardized makes of jacketed condensers. To correct this situation without in any other way affecting the test, the committee recommends that it be revised as follows and referred to letter ballot of the Society for adoption as standard:

Section 4.—Change from its present form to read as follows:

> 4. The condenser shall consist of a 250-mm. standard glass-jacketed condenser. The following dimensions are recommended (see Fig. 3):

Length of jacket excluding the necks........................	250 mm. ± 5 mm.
Outside diameter of adapter of condenser tube................	23 mm. ± 1 mm.
Length of adapter..	75 mm. ± 5 mm.
Outside diameter of condenser tube proper...................	12.5 mm. ± 0.5 mm.
Over-all length of condenser tube including adapter..........	475 mm. ± 25 mm.

Section 5.—Change the last sentence to read as follows by the addition of the italicized words and figure:

> The outlet end shall be ground to an angle of 45 deg. ***plus or minus 5 deg.*** with the inside vertical.

Fig. 3.—Correct the dimensions of the distillation apparatus assembly shown in Fig. 3 of the method to correspond with the changes recommended in Section 4 above, and in addition, change the distance of the thermometer to end of condenser tube from "500 to 600 mm." to read "600 to 700 mm."

Section 12 (a).—In connection with the size of sample prescribed in the first sentence of this section for the distillation test, namely, 200 ml., add the following as a footnote:

> In the case of persistently foaming material, one-half of this amount may be employed.

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[1] 1934 Supplement to Book of A.S.T.M. Standards, p. 127.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, p. 938 (1934); also 1935 Book of A.S.T.M. Tentative Standards, p. 855.

Section 12 (b).—In order to avoid possible misunderstanding as to the intent of this section it is recommended that the word "uniformity" be substituted for "homogeneity."

III. *Revisions of Tentative Standards:*

The committee recommends that the following four specifications be revised as indicated and continued as tentative:

Tentative Specifications for Emulsified Asphalt (for Coarse Aggregate Plant Mixes) (D 397 – 34 T):[1]

Section 1 (b).—Change the requirement for viscosity and miscibility with water to read as follows by the omission of the words and figures in brackets and the addition of the italicized word:

Viscosity, Saybolt Furol, 60 ml. at 25 C. (77 F.)	not less than 100 sec., [and] [not more than 700 sec.]
Miscibility with water	no appreciable [separation] *coagulation* in 2 hr.

Section 1 (c).—Change the present requirement for percentage soluble in carbon disulfide now specified as "not less than 95 per cent" to read "not less than 97.5 per cent for petroleum asphalts or 95 per cent for native asphalts."

Tentative Specifications for Emulsified Asphalt (for Retread and Coarse Aggregate Mixes) (D 398 – 34 T)[1] *and for Emulsified Asphalt (Heavy Premix—Summer Grade) (D 399 – 34 T)*:[1]

Section 1 (b).—In the requirement for miscibility with water, change the word "separation" to read "coagulation."

Section 1 (c).—Make the same change in the requirement for percentage soluble in carbon disulfide in this section as recommended in Section 1 (*c*) of Specifications D 397 – 34 T, above.

Tentative Specifications for Emulsified Asphalt ((Quick-Setting) for Penetration and Surface Treatment) (D 401 – 34 T):[1]

Section 1 (b).—Change the requirement for demulsibility (35 ml. of 0.02 *N* $CaCl_2$) from "not less than 50 per cent" to read "not less than 60 per cent."

Section 1 (c).—Make the same change in the requirement for percentage soluble in carbon disulfide in this section as recommended in Section 1 (*c*) of Specifications D 397 – 34 T, above.

IV. *Reversion of Standards to Tentative:*

Because of contemplated extensive revisions, it is recommended that the following standard specifications be reverted to tentative:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, pp. 916 to 925 (1934); also 1935 Book of A.S.T.M. Tentative Standards, pp. 814 to 823.

Standard Specifications for:

High-Carbon Tar for Surface Treatment, Cold Application (D 104 – 30),[1]
Low-Carbon Tar for Surface Treatment, Cold Application (D 105 – 30),[1]
High-Carbon Tar for Surface Treatment, Hot Application (D 108 – 30),[1]
Low-Carbon Tar for Surface Treatment, Hot Application (D 109 – 30),[1]
High-Carbon Tar Cement (D 110 – 30),[1] and
Low-Carbon Tar Cement (D 111 – 30).[1]

V. *Withdrawal of Tentative Standard:*

Because it is considered as unnecessary and misleading in connection with its title, it is recommended that the Tentative Specifications for Emulsified Asphalt (Heavy Premix—Winter Grade) (D 400 – 34 T)[2] be withdrawn.

VI. *Tentative Standards Continued as Tentative:*

In connection with the tentative standards for which it is responsible and which have been published for three or more years without revision, Committee D-4 regrets that it is unable at this time to recommend their adoption as standard. It hopes, however, to include definite recommendations regarding them in its next annual report.

The recommendations appearing in this report have been submitted to letter ballot of the committee, which consists of 98 members, the results being as follows:

Items	Affirmative	Negative	Ballots Marked "Not Voting"
I. REVISION OF STANDARD			
Method of Test for Loss on Heating of Oil and Asphaltic Compounds (D 6 – 33), editorial change	62	0	8
II. ADOPTION OF TENTATIVE STANDARDS AS STANDARD			
Method of Test for Residue of Specified Penetration (D 243 – 35 T)	61	2	8
Volume Correction Table for Asphaltic Products (D 206 – 34)	63	0	8
Method of Test for Separation of Liquid Asphaltic Products (D 402 – 34 T), as revised	60	0	6
III. REVISION OF TENTATIVE STANDARDS			
Specifications for Emulsified Asphalt (for Coarse Aggregate Plant Mixes) (D 397 – 34 T)	56	2	9
Specifications for Emulsified Asphalt (for Retread and Coarse Aggregate Mixes) (D 398 – 34 T)	56	2	9
Specifications for Emulsified Asphalt (Heavy Premix—Summer Grade) (D 399 – 34 T)	56	2	9
Specifications for Emulsified Asphalt ((Quick-Setting) for Penetration and Surface Treatment) (D 401 – 34 T)	53	4	10
IV. REVERSION OF STANDARDS TO TENTATIVE			
Specifications for High-Carbon Tar for Surface Treatment, Cold Application (D 104 – 30)	52	1	14
Specifications for Low-Carbon Tar for Surface Treatment, Cold Application (D 105 – 30)	54	1	12
Specifications for High-Carbon Tar for Surface Treatment, Hot Application (D 108 – 30)	54	1	12
Specifications for Low-Carbon Tar for Surface Treatment, Hot Application (D 109 – 30)	54	1	12
Specifications for High-Carbon Tar Cement (D 110 – 30)	54	1	12
Specifications for Low-Carbon Tar Cement (D 111 – 30)	54	1	12
V. WITHDRAWAL OF TENTATIVE STANDARD			
Specifications for Emulsified Asphalt (Heavy Premix—Winter Grade) (D 400 – 34 T)	56	2	9

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[1] 1933 Book of A.S.T.M. Standards, Part II, pp. 932 to 942.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, p. 922 (1934); also 1935 Book of A.S.T.M. Tentative Standards, p. 820.

The election of officers for the ensuing term of two years resulted in the selection of the following:

Chairman, F. C. Lang
First Vice-Chairman, E. F. Kelley
Second Vice-Chairman, A. T. Goldbeck
Third Vice-Chairman, E. O. Rhodes
Secretary, Prévost Hubbard

This report has been submitted to letter ballot of the committee, which consists of 98 members; 72 members returned their ballots, of whom 68 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

M. H. ULMAN,
Chairman.

PRÉVOST HUBBARD,
Secretary.

EDITORIAL NOTE

Subsequent to the annual meeting Committee D-4 on Road and Paving Materials in cooperation with Committee C-9 on Concrete and Concrete Aggregates presented to the Society on August 26, 1936, through Committee E-10 on Standards the following two proposed tentative methods of test:

Proposed Tentative Methods of:

- Test for Specific Gravity and Absorption of Coarse Aggregate, to replace the Standard Method of Test for Apparent Specific Gravity of Coarse Aggregates (D 30 – 18) and the Tentative Method of Test for Apparent Specific Gravity of Coarse Aggregates in a Saturated Condition (C 86 – 31 T).
- Test for Specific Gravity and Absorption of Fine Aggregate, to replace the Standard Methods of Test for Apparent Specific Gravity of Sand, Stone and Slag Screenings, and Other Fine Non-Bituminous Highway Materials (D 55 – 25) and the Standard Method of Test for Approximate Apparent Specific Gravity of Fine Aggregate (C 68 – 30).

The proposed tentative methods of test were accepted and appear on pp. 805 and 808, respectively.

REPORT OF COMMITTEE D-5

ON

COAL AND COKE

Committee D-5 on Coal and Coke held two meetings during the past year; one on June 27, 1935, at the annual meeting of the Society in Detroit, Mich., and the other on March 4, 1936, at the spring group meetings of A.S.T.M. committees held in Pittsburgh, Pa.

Subcommittee V on Tolerances has been discontinued and the question of tolerances for the methods of test sponsored by Committee D-5 has been assigned to the subcommittees responsible for the development of the test methods.

A new subcommittee, under the chairmanship of Mr. O. O. Malleis and designated as Subcommittee XIV on Dustiness of Coal and Coke, has been formed to prepare a method of test for dustiness of coal and coke. The treatment of coal and coke by chemicals and oil compounds to allay dust and give a clean fuel is coming into greater use so it is desirable to have a standard test method to determine the efficiency of such treatment.

During the year, five standard methods of test under the jurisdiction of Committee D-5 have been approved as American Standards by the American Standards Association, as follows:

Standard Methods of:

Test for Cubic Foot Weight of Crushed Bituminous Coal (D 291 - 29) (A.S.A. No. K20.1-1936)
Test for Cubic Foot Weight of Coke (D 292 - 29) (A.S.A. No. K20.2-1936)
Tumbler Test for Coke (D 294 - 29) (A S.A. No. K20.3-1936)
Shatter Test for Coke (D 141 - 23) (A.S.A. No. K20.4-1936)
Test for Volume of Cell Space of Lump Coke (D 167 - 24) (A.S.A. No. K20.5-1936)

RECOMMENDATIONS AFFECTING STANDARDS

Proposed Revision of Standard.—The Standard Methods of Laboratory Sampling and Analysis of Coal and Coke (D 271 - 33)[1] contain a modified procedure for the determination of volatile matter of subbituminous coal, lignite and peat, which fuels are given a preliminary heat treatment to prevent the too rapid evolution of moisture and gases. Certain low-temperature cokes, green cokes, chars, anthracites and semianthracites should also be given such a preliminary heat treatment but no reference is made to these fuels in the standard. Also, it is believed advisable to include in the standard more detailed instructions for this modified method of determining volatile matter. The committee accordingly recommends that the revision appended hereto[1] be accepted for publication as tentative.

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 269.

This recommendation has been referred to letter ballot of the committee, which consists of 43 members; 41 members returned their ballots, of whom 39 have voted affirmatively, 1 negatively and 1 marked his ballot "not voting."

Tentative Standards Continued as Tentative.—The Tentative Definition of the Term Coke (D 121 – 30 T) is being continued as tentative pending agreement on a definition that will be acceptable to both Committee D-5 and Committee D-2 on Petroleum Products and Lubricants.

The following tentative standards are being continued as tentative to afford further opportunity for criticisms:

Tentative Methods of:

Test for Grindability of Coal by Ball-Mill Method (D 408 – 35 T)
Test for Grindability of Coal by Hardgrove Machine Method (D 409 – 35 T)
Test for Screen Analysis of Coal (D 410 – 35 T)
Tentative Definition of the Terms Gross Calorific Value and Net Calorific Value of Fuels (D 407 – 35 T)

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Methods of Testing (W. A. Selvig, chairman).—Tests have been continued in the search for a source of sand of sufficiently uniform surface characteristics for use as inert material in the agglutinating value test for coal. Sands were tested from Illinois, Oklahoma, Michigan, New Jersey and California. The extreme sensitivity of this test to differences in surface characteristics of the sand grains is shown by a large variation in results when these sands were tested with the same coal, as the agglutinating values at the 15 to 1 ratio of sand to coal ranged from 2.7 kg. for a Michigan sand to 9.3 kg. for a New Jersey sand. As the test method is so sensitive to slight differences in surface characteristics of the inert material, it is probable that no source of sand can be found which is sufficiently uniform so that different shipments will give identical results with the same coal. A practical solution to this problem would be to have a large quantity of a well-mixed, satisfactory sand stocked by someone as a source of supply.

Check determinations were made by different laboratories of coal-ash fusibility by the Barrett coal-ash fusion furnace and by the gas furnace specified in the Standard Methods of Laboratory Sampling and Analysis of Coal and Coke (D 271 – 33). These results proved to be sufficiently promising to justify further investigation with a view to acceptance of this new furnace as permissible equipment in the standard method of test. The softening temperatures as determined by the Barrett furnace showed a general tendency to be a little lower than those as determined by the furnace specified in the standard method. This difference averaged about 25 F. (14 C.) for the coal ashes tested.

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[1] See p. 1206.

Subcommittee I, with the aid of coal chemists experienced in the determination of volatile matter in coal, prepared the proposed revision of this standard method given elsewhere in this report.

Subcommittee II on Nomenclature and Definitions (H. C. Porter, chairman).—Committee D-5 was requested by the headquarters of the Society to make recommendations regarding the most appropriate terminology to express the heat produced by combustion of fuels so a uniform nomenclature could be adopted in standards relating to coal, coke, fuel oil, and gaseous fuel. The subcommittee has recommended that the term "calorific value" be used for expressing heat of combustion of fuels and this recommendation has been approved by Committee D-5.

Subcommittee VII on Pulverizing Characteristics of Coal (John Van Brunt, chairman).—A meeting of this subcommittee was held in New York City on February 20, 1936. During the past year, work has been done on the ball-mill method and the Hardgrove machine method for the determination of grindability of coal, which methods were published last year as tentative standards. Two papers covering this work were presented at a meeting of the Coal Division of the American Institute of Mining and Metallurgical Engineers held in New York City on February 17, 1936, as follows: "Investigation of Procedure for Determination of Coal Grindability by the Ball-Mill Method" by C. G. Black, covering work done at the Central Laboratory of the Pittsburgh Coal Co.; and "Further Investigation of Methods for Estimating the Grindability of Coal" by H. F. Yancey and M. R. Geer, covering work done at the Northwest Experiment Station of the U. S. Bureau of Mines. The authors of these two papers have suggested changes in the two tentative methods. These proposed revisions will be given consideration by the subcommittee during the year.

Subcommittee XI on Coal Friability (R. E. Gilmore, chairman).—This subcommittee held a meeting in New York City on February 20, 1936. The committee has practically completed its task of formulating methods of test for friability of coal. The two methods under consideration are a drop shatter test and a tumbler test. Experimental work leading to the development of these methods, and the proposed methods, are described in the Canada Department of Mines *Publication No. 762* (1935), "Coal Friability Tests: A Comparative Study of Methods for Determining the Friability of Coal and Suggestions for Tumbler and Drop Shatter Test Methods" by R. E. Gilmore, J. H. H. Nicolls, and G. P. Connell. The methods as given in this publication, with some revisions, will be subsequently recommended by this subcommittee as proposed tentative standards.

Subcommittee XIII on Mechanical Sampling and Reduction of Samples (J. B. Morrow, chairman).—This subcommittee held a meeting on March 4, 1936, in Pittsburgh, Pa. A procedure for the mechanical crushing and reduction of gross samples of coal to convenient size for transmittal to the laboratory has been accepted for study. By this method the entire gross sample is crushed to pass a No. 4 sieve and is then divided on a riffle sampler to 10 lb. This 10-lb. sample is further crushed so at least 95 per cent passes a No. 8 sieve and is divided on a riffle sampler to not less than 1½ lb. The subcommittee intends to investigate methods of collection of representative gross samples and a special group has been assigned this phase of the sampling problem.

Subcommittee XIV on Dustiness of Coal and Coke (O. O. Malleis, chairman).—This subcommittee has prepared for study a procedure for the determination of dustiness of coal and coke based on a method described in the paper "Method for Determining the Dustiness of Coal and Coke," by A. R. Powell and C. C. Russell.[1] This method is to be investigated by different laboratories to determine its suitability for testing dustiness of coal and coke.

The election of officers for the ensuing term of two years resulted in the re-election of the present incumbents.

This report has been submitted to letter ballot of the committee, which consists of 43 members; 41 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

A. C. FIELDNER,
Chairman.

W. A. SELVIG,
Secretary.

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[1] *Industrial and Engineering Chemistry*, Analytical Edition, Vol. 5, p. 340 (1933).

REPORT OF SECTIONAL COMMITTEE
ON
CLASSIFICATION OF COALS

A.S.A. PROJECT: M 20

The Sectional Committee on Classification of Coals, functioning under the procedure of the American Standards Association, held two meetings within the year: the annual meeting at the time of the American Institute of Mining and Metallurgical Engineers' meeting in New York City, on February 21, 1936, and a special meeting at the U. S. Bureau of Mines in Pittsburgh, Pa., on May 18, 1936.

The following officers were elected for the ensuing two-year period: chairman, A. C. Fieldner; vice-chairman, H. J. Rose; secretary, J. D. Battle; executive committee, George H. Ashley, W. H. Fulweiler, R. E. Gilmore, T. W. Harris, Jr., and E. W. Parker. G. B. Southward was appointed as alternate representative of the American Mining Congress on the Sectional Committee *vice* Henry Mace Payne who resigned on account of change of work.

Within the past year an application of the present tentative specifications for the rank and grade classification to Illinois coals has been published by the Illinois State Geological Survey.[1] Further investigation of methods for defining the caking properties of coal has led to the substitution of the agglomerating test for the agglutinating test as an aid in differentiating between semianthracite and low-volatile bituminous coal and between high-volatile C bituminous coal and subbituminous A coal. A method for designating the size of coal from its screen analysis has been developed and is being recommended for publication as tentative. Substantial progress has been made in the preparation of a series of charts giving factors recommended for consideration in the selection of coal for various uses. The classification of coals by type has progressed slowly because of lack of fundamental information; additional work is being conducted to supply this need.

Although no revisions have been made during the year of the tentative specifications for the classification of coals by grade, it is recommended that both rank and grade specifications be continued as tentative for another year. These specifications have been recommended to the American Standards Association for approval as American Tentative Standards.

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[1] G. H. Cady, "Classification and Selection of Illinois Coals," Illinois State Geological Survey *Bulletin 62* (1935).

RECOMMENDATIONS AFFECTING STANDARDS

Proposed Revision of Tentative Specifications for Classification of Coals by Rank (D 388 – 35 T).—The committee recommends that the revisions proposed by the Technical Committee on Coal Classification as given under the section Activities of Technical Committees be accepted for publication as tentative.

The committee further recommends that the Method for Designating the Size of Coal from Its Screen Analysis, proposed by the Technical Committee on Coal Classification, and appended to this report,[1] be accepted for publication as tentative.

The above recommendations have been submitted to letter ballot of the committee which consists of 28 members; 26 members returned their ballots, the results being as follows:

Items	Affirmative	Negative	Ballots Marked "Not Voting"
I. PROPOSED TENTATIVE STANDARD			
Method for Designating the Size of Coal from Its Screen Analysis	22	0	4
II. PROPOSED REVISION OF TENTATIVE STANDARD			
Specifications for Classification of Coals by Rank (D 388 – 35 T)	24	0	2

ACTIVITIES OF TECHNICAL COMMITTEES

Technical Committee on Coal Classification (H. J. Rose, chairman).—During the past year the committee held two meetings; one in Washington, D. C., November 7, 1935, and the other in New York City, February 21, 1936. The Tentative Specifications for Classification of Coals by Rank (D 388 – 35 T) with a revision substituting agglomeration for agglutination, and the Tentative Specifications for Classification of Coals by Grade (D 389 – 34 T) are recommended for continuation as tentative, in order to afford further opportunity for criticism. A Method for Designating the Size of Coal from Its Screen Analysis is recommended for publication as tentative, as appended hereto.[1]

The committee continued active work throughout the year, through its subcommittees, as follows:

Subcommittee II on Origin and Composition of Coal and Methods of Analysis (A. C. Fieldner, chairman) held two meetings during the past year; one in Washington, D. C., on November 6, 1935, and one in New York City on February 20, 1936. Work has been continued on the study of the microstructure of coals with reference to origin and type classification by the subcommittee members connected with the Illinois Geological

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[1] See p. 819.

Survey, the U. S. Geological Survey, and the U. S. Bureau of Mines.[1] Sufficient information has not been obtained as yet to justify the formulation of specifications for the classification of coals according to type. However, the subcommittee has reached tentative agreement that the types of coal should be classified into two groups, namely, banded and nonbanded coals, and that these two groups should each be subdivided into three classes making six classes of coal types. It is hoped that in another year tentative specifications for type may be submitted to the technical committee for consideration.

This subcommittee has continued cooperation with other agencies on the development of standard methods for determining true mineral matter,[2, 3] friability,[4] grindability,[5, 6, 7] agglutinating[8] and agglomerating values, and analysis.[9]

Subcommittee V on Boundary Lines for Coal Classification (W. A. Selvig, chairman) held a meeting in New York City on February 20, 1936. A classification chart of typical coals of the United States showing B.t.u. per pound on the moist, mineral-matter-free basis plotted against fixed carbon on dry, mineral-matter-free basis has been published by the U. S. Bureau of Mines.[10] This chart, when used in conjunction with the present tentative specifications for classification of coals by rank, is a convenient means of showing the position of typical coals of the United States in the scale of rank.

For the past two years the subcommittee has been accumulating data and making tests on various coals regarding the feasibility of substituting an agglomeration test for the agglutinating value test as given in the Tentative Specifications for Classification of Coals by Rank (D 388 - 35 T). The agglomeration test has the advantage of simplicity because no special apparatus is needed. The agglomerating characteristics of coals are judged by examination of the residue in the platinum crucible incident to the volatile matter determination. The Canadian members of the subcommittee recommended the agglomeration test in preference to the agglutinating value test as being more suitable for use in the classification of Canadian coals. All available data on coals of the United States now classified as semianthracite, low-volatile bituminous coal, high-volatile C bituminous coal, or subbituminous A coal show that the classification of none of these coals would be changed if the agglomeration test were substituted for the agglutinating value test.

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[1] R. Thiessen and G. C. Sprunk, "Microscopic and Petrographic Studies of Certain American Coals," U. S. Bureau of Mines *Technical Paper 564* (1935).

[2] G. Thiessen, C. G. Ball and P. E. Grotts, "Coal Ash and Coal Mineral Matter," *Industrial and Engineering Chemistry*, Vol. 28, pp. 355–361 (1936).

[3] C. G. Ball, "Contributions to the Study of Coal. Mineral Matter of No. 6 Bed Coal at West Frankfort, Franklin County, Illinois," Illinois State Geological Survey *Report of Investigations 33* (1935).

[4] R. E. Gilmore, J. H. H. Nicolls and G. P. Connell, "Coal Friability Tests," Canada Department of Mines *Publication 762* (1935).

[5] H. F. Yancey and M. R. Geer, "Further Investigation of a Method for Estimating the Grindability of Coal," Am. Inst. Mining and Metallurgical Engrs., Coal Division, *Contribution 94—F* (1936).

[6] C. G. Black, "Investigation of Procedure for Determination of Coal Grindability by the Ball-Mill Method," Am. Inst. Mining and Metallurgical Engrs., Coal Division, *Contribution 95—F* (1936).

[7] W. A. Selvig, "Check Determinations of Grindability of Coal by Various Methods," U. S. Bureau of Mines *Report of Investigations 3301* (1936).

[8] F. H. Fish, "The Agglutinating Value of Some Lower Volatile Virginia Coals," Virginia Polytechnic Institute, Engineering Experiment Station *Bulletin 20* (1935).

[9] W. R. Kirner, "Microchemical Analysis of Solid Fuels," *Industrial and Engineering Chemistry*, Analytica Edition, Vol. 7, pp. 294–299 (1935).

[10] A. C. Fieldner, W. A. Selvig and W. H. Frederic, "Classification Chart of Typical Coals of the United States," U. S. Bureau of Mines *Report of Investigations 3296* (1935).

The subcommittee recommends the following revisions in the Tentative Specifications for Classification of Coals by Rank (D 388 – 35 T):[1]

Section 3 (c).—Change from its present form: namely,

> (*c*) *Agglutinating Index.*—Coals having average agglutinating indices of 500 g. or more at a ratio of 15 parts sand to 1 part coal shall be considered agglutinating from the standpoint of classification.

to read as follows:

> (*c*) *Agglomerating Index.*—Coals which in the volatile matter determination produce either an agglomerate button that will support a 500-g. weight without pulverizing, or a button showing swelling or cell structure, shall be considered agglomerating from the standpoint of classification.

Section 9.—Change from its present form: namely,

> 9. Pending consideration of an agglomeration test now being investigated, the agglutinating index shall be determined in accordance with the Proposed Method of Test for Agglutinating Value of Coal, published as information by the American Society for Testing Materials.

to read as follows:

> 9. Pending the adoption of a method by the American Society for Testing Materials the coke-button grading test[a] afforded by the examination of the residue in the platinum crucible incident to the volatile matter determination, shall be used.

Substitute the word "agglomerating" for the word "agglutinating" wherever the latter occurs in Table I and in the text of the specifications.

These recommendations were adopted at the New York meeting of the technical committee and referred to letter ballot of the committee which consists of 32 members; 31 members returned their ballots, of whom 29 voted affirmatively, 1 negatively and 1 marked his ballot "not voting."

Subcommittee VI on Correlation of Scientific Classification with Use Classification of Coals (T. W. Harris, Jr., chairman) held two meetings during the year: one in Washington, D. C., on November 6, 1935, and one in New York City on February 20, 1936. This subcommittee has prepared a series of seven charts of "Factors Recommended for Consideration in the Selection of Coal" and has had these charts filled in by a number of experts to show the relative importance of each factor for the various uses of coal. The mass of information obtained is now being correlated. The principal purpose of the completed charts will be to indicate which chemical and physical factors should receive particular consideration when selecting coals for specific uses.

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[a] R. E. Gilmore, G. P. Connell and J. H. H. Nicolls, "Agglomerating and Agglutinating Tests for Classifying Weakly Caking Coals," *Transactions*, Am. Inst. Mining and Metallurgical Engrs., Coal Division, Vol. 108, p. 255 (1934).

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 847 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 617.

Subcommittee VII on Defining Coal Sizes and Friability (J. D. Doherty, chairman) held two meetings during the year: one in Pittsburgh, Pa., on October 7, 1935, and one in Washington, D. C., on November 6, 1935. A proposed "Method for Designating the Size of Coal from Its Screen Analysis" was recommended to the technical committee for consideration. It provides a convenient and condensed method for describing the size of coal from screen test results, based on upper and lower limiting screens which result in designated percentages of oversize and undersize. This method with some revisions, as appended hereto,[1] is recommended for publication as tentative. This recommendation was adopted at the New York meeting of the technical committee and referred to letter ballot of the committee which consists of 32 members; 31 members returned their ballots, of whom 25 voted affirmatively, 0 negatively and 6 marked their ballots "not voting."

This report has been submitted to letter ballot of the committee which consists of 28 members; 24 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

A. C. FIELDNER,
Chairman.

J. D. BATTLE,
Secretary.

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[1] See p. 819.

REPORT OF COMMITTEE D-7
ON
TIMBER

Committee D-7 on Timber has carried on its work through its subcommittees, several of which have been very active during the past year, with the result that detailed reports were presented by them to the committee.

Recommendations Affecting Standards

The recommendations affecting standards and tentative standards are noted in brief form below, together with the results of the letter ballot. These recommendations are explained in the reports of the subcommittees directly responsible for them.

I. Proposed Tentative Standard.—The committee recommends for publication as tentative the proposed Tentative Specifications for Zinc Chloride, appended hereto,[1] as proposed by Subcommittee VI on Timber Preservatives.

II. Proposed Revisions of Standards.—Revisions are proposed in two standards for immediate adoption and in one standard for publication as tentative, as follows:

The committee presents for immediate adoption revisions in the following two standard specifications as proposed by Subcommittee VI on Timber Preservatives and accordingly asks for the necessary nine-tenths vote at the annual meeting in order that these modifications may be referred to letter ballot of the Society for immediate adoption:

Standard Specifications for Creosote (D 390 – 35)
Standard Specifications for Creosote – Coal Tar Solution (D 391 – 35)

The committee recommends a revision of the Standard Specifications for Structural Wood Joist and Planks, Beams and Stringers, and Posts and Timbers (D 245 – 33) in the form of separate tentative specifications, appended hereto,[2] as submitted by Subcommittee I on Specifications for Timber. With the acceptance as tentative of the revised specifications the existing standard specifications are to be withdrawn.

The recommendations appearing in this report have been submitted to letter ballot of the committee, which consists of 24 members; 24 members returned their ballots, the results being as follows:

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[1] See p. 847.
[2] See p. 823.

Items	Affirmative	Negative	Ballots Marked "Not Voting"
I. PROPOSED TENTATIVE STANDARD			
Specifications for Zinc Chloride	20	0	4
II. PROPOSED REVISIONS OF STANDARDS			
Specifications for Creosote (D 390 – 35), immediate adoption	20	0	4
Specifications for Creosote – Coal Tar Solution (D 391 – 35), immediate adoption	20	0	4
Specifications for Structural Wood Joist and Planks, Beams and Stringers, and Posts and Timbers (D 245 – 33)	21	0	3

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Specifications for Timber (C. E. Paul, chairman).—Subcommittee I submitted last year for publication as information a proposed revision[1] of the Standard Specifications for Structural Wood Joist and Planks, Beams and Stringers, and Posts and Timbers (D 245 – 33). The new form in which the rules were written does not in any way change the principles underlying the Standard Specifications D 245 as adopted as standard by the Society in 1933.[2] It represents a method of rearrangement and the substitution of working stress values for the grade names given in the Standard Specifications D 245 as now published.[2] For instance, instead of calling one of the grades of Douglas fir or Southern pine "Dense Select Structural Beams and Stringers," the revised specification designates this grade "1800 lb. *f* Structural Beams and Stringers." This method provides structural grades designated in terms of the requirements of design and conforms to practical commercial manufacturing conditions.

The proposed revision of these standard specifications has been modified this year by deleting those sections relating to all species and grades where the stresses shown were not those advocated by the U. S. Forest Products Laboratory.

The subcommittee recommends that this modification of the proposed revision of the Standard Specifications for Structural Wood Joist and Planks, Beams and Stringers, and Posts and Timbers (D 245 – 33), as appended hereto,[3] be submitted to the Society for publication as tentative to replace the existing standard specifications.

Subcommittee I has received no further suggestions for revision of its Tentative Specifications for Timber Piles (D 25 – 34 T) which have been in effect during the past year and it was accordingly intended to recommend their adoption as standard this year. After the subcommittee had held its meeting in Chicago in March, 1936, however, the question of a possibility of excessive bending stresses in extra long piles having the smaller sizes of tips, during lifting or handling incidental to driving and due to their own weight, was brought to the attention of the subcommittee. Investigations were made by one of the members of the subcommittee which indicate it would be wise possibly to revise a limited number of sizes in the present tentative specifications. In view of the fact that there was not sufficient time left for committee action this year, it was thought best to continue the specifications as tentative until a careful consideration of methods of handling piles and an analysis of the incidental stresses can be made and discussed by the subcommittee during the coming year.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 364 (1935).
[2] 1933 Book of A.S.T.M. Standards, Part II, p. 347.
[3] See p. 823.

Subcommittee VI on Timber Preservatives (S. R. Church, chairman).—This subcommittee recommends that the proposed Tentative Specifications for Zinc Chloride, as appended hereto,[1] be submitted to the Society for publication as tentative. These specifications are identical in substance with the Standard Specification for Zinc Chloride (No. 17a) of the American Wood-Preservers' Association.[2] The reason for recommending specifications for zinc chloride is that this material is the widely accepted preservative for salt treatment of timber. The use of salt treatments is becoming more wide-spread for lumber and in building construction.

The subcommittee also recommends that the revisions in the following two standards be approved for reference to letter ballot of the Society for immediate adoption:

Standard Specifications for Creosote (*D 390 – 35*).[3]—Delete from these specifications the following provisions respecting the float test of creosote:

Section 2.—Delete the following requirement:

Float test at 70 C. of residue above 355 C. if it exceeds 5 per cent.. not more than 50 sec.

Section 3.—Delete the following reference in Paragraph (*g*) relettering the remaining paragraphs accordingly:

(*g*) *Float Test of Residue.*—Standard Method of Float Test for Bituminous Materials (A.S.T.M. Designation: D 139).

Standard Specifications for Creosote – Coal Tar Solution (*D 391 – 35*).[3]—Delete from these specifications the following provisions respecting the float test of creosote – coal tar solution:

Section 2.—Delete the following requirement:

Float test at 70 C. of residue above 355 C. if it exceeds 26 per cent.. not more than 50 sec.

Section 3.—Delete the following reference in Paragraph (*g*) relettering the remaining paragraphs accordingly:

(*g*) *Float Test of Residue.*—Standard Method of Float Test for Bituminous Materials (A.S.T.M. Designation: D 139).

The reason for recommending the omission of the float test requirement from these specifications is that this test has been found in numerous cases to be unsatisfactory. It was originally intended to act as a safeguard against adulteration of creosote with tar. Results obtained by numerous members of the Preservatives Committee of the A.W.P.A., including members of Subcommittee VI, have revealed that some entirely authentic and unmixed creosotes failed to comply with the tests. The committees of the American Wood-Preservers' Association and the American Railway Engineering Association have recommended the same modification in the standards of these organizations.

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[1] See p. 847.
[2] *Manual of Recommended Practice*, Am. Wood-Preservers' Assn.
[3] 1935 Supplement to Book of A.S.T.M. Standards, pp. 202, 204.

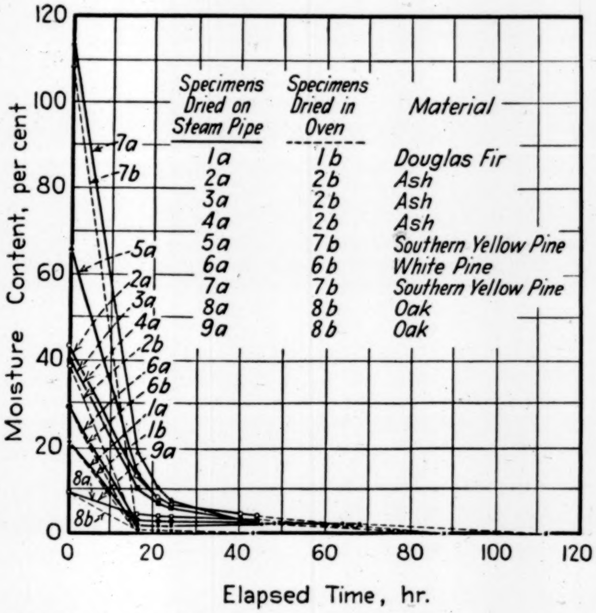


FIG. 1.—Comparison of Drying Rates in an Oven and Over a Steam Pipe for Determining Moisture Content of Timber.

The subcommittee is recommending no action at present on a proposed method for the determination of tar acids because of the withdrawal for further revision of a method that the Preservatives Committee of the A.W.P.A. expected to present at the last annual meeting of that association.

The work of the subcommittee during the coming year will include the following: (1) Methods of sampling creosote – coal tar solution and coal tar, (2) continue to develop method of determining tar acids, and (3) continue to develop a definition for term "coal tar" as used in wood preserving.

Subcommittee XI on Moisture Content of Timber (M. E. Dunlap, chairman).—During the year Subcommittee XI has given consideration to laboratory methods for the determination of moisture content of timber.

Some work still remains to be done before such methods will be ready for presentation to the Society for publication as tentative.

At the meeting of Committee D-7 in Chicago on March 11, 1936, the Chairman, Hermann von Schrenk, pointed out the need for a method of oven drying which could be carried out by rather rudimentary means in order that the operator who does not have facilities for the conduct of laboratory tests may roughly check the condition of material being processed. Mr. J. A. Newlin suggested the use of steam pipes for oven drying and has since furnished the data shown in Fig. 1. The samples were dried in the positions shown in Fig. 2. The solid lines of the curves in Fig. 1 indicate the drying time and the moisture contents reached by the samples when dried in the positions on the steam pipe as shown in Fig. 2. The test results on similar samples tested in an oven are shown by the dotted lines in Fig. 1. Samples ultimately reached a more or less steady state between 2 and 4 per cent of moisture. The time required for drying on the steam pipes was between 24 and 40 hr. The samples placed in the oven were reduced in moisture content to 0.5 per cent or less in 16 hr. The remainder of the moisture was lost in 24 to 40 hr. The exposure of samples over a steam pipe as shown in Fig. 2 would be more or less subject to prevailing humidity conditions and would produce greater or less error on this account.

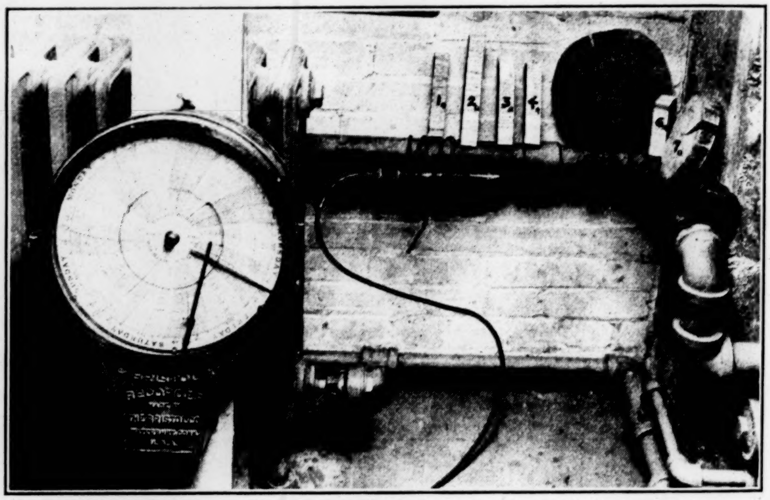
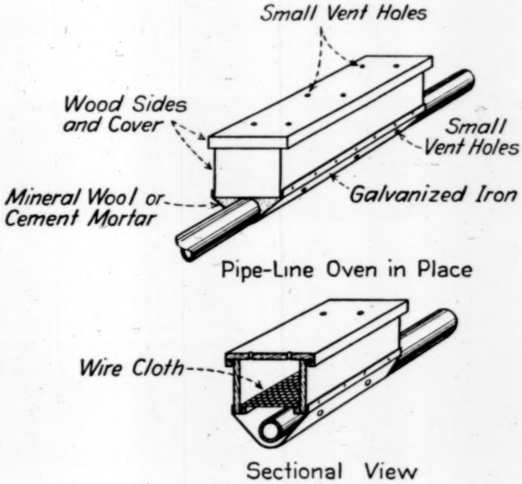


FIG. 2.—Position of Samples Dried Over Steam Pipe (see Fig. 1).

Because steam pipes are nearly always available about a woodworking plant, the "steam pipe oven" is suggested as a simple means of oven-drying samples. Before placing the oven over the steam pipe the pipe covering should be removed from the pipe for a distance equal to the length of the oven. After the oven is in place the ends should be closed with mineral wool or cement mortar as illustrated in Fig. 3. This device, shown in Fig. 3, could be easily built and with an inexpensive scale could be used to obtain satisfactory moisture content determinations. Ovens of this type will be tested by the subcommittee during the year.


Small Vent Holes
Wood Sides and Cover
Small Vent Holes
Mineral Wool or Cement Mortar
Galvanized Iron
Wire Cloth

Pipe-Line Oven in Place

Sectional View

FIG. 3.—Steam Pipe Oven.

The election of officers for the ensuing term of two years resulted in the re-election of the present incumbents.

This report has been submitted to letter ballot of the committee which consists of 24 members; 24 members returned their ballots, of whom 22 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

HERMANN VON SCHRENK,
Chairman.

J. A. NEWLIN,
Secretary.

REPORT OF COMMITTEE D-8
ON
BITUMINOUS WATERPROOFING AND ROOFING MATERIALS

Committee D-8 on Bituminous Waterproofing and Roofing Materials has held two meetings during the past year, in Atlantic City, N. J., on June 27, 1935, and in Pittsburgh, Pa., on March 5, 1936.

Recommendations Affecting Standards

I. Adoption of Tentative Standard as Standard.—In its 1935 annual report, Committee D-8 joined with Committee D-4 on Road and Paving Materials in recommending that the tables designated as Group 0 and Group 1 in the Standard Abridged Volume Correction Table for Petroleum Oils (D 206 – 34)[1] be tentatively approved as a Volume Correction Table for Asphaltic Products. This recommendation was accepted by the Society but instead of issuing the tables for these groups as a separate tentative standard which would involve duplication in publication, a footnote indicating this tentative approval was added to the tables for Group 0 and Group 1 in Standard D 206 – 34. As these tables are now in common use by the producers and consumers of asphaltic products, Committee D-8 joins with Committee D-4 in recommending that their use for these products be formally approved by the Society as standard and that the present footnote be changed to read as follows:

> These tables for Group 0 and Group 1 have been adopted as standard by the Society as volume correction tables for asphaltic products, on the joint recommendation of Committee D-4 on Road and Paving Materials and Committee D-8 on Bituminous Waterproofing and Roofing Materials.

II. Reversion of Standards to Tentative.—Because of contemplated extensive revisions, it is recommended that the following standards[2] be reverted to tentative:

Standard Specifications for:

- High-Carbon Coal-Tar Pitch for Use in Damp-proofing and Waterproofing Below Ground Level (D 42 – 25),
- High-Carbon Coal-Tar Pitch for Use in Damp-proofing and Waterproofing Above Ground Level (D 145 – 25),
- High-Bitumen Coal-Tar Pitch for Use in Damp-proofing and Waterproofing Below Ground Level (D 200 – 25),
- High-Bitumen Coal-Tar Pitch for Use in Damp-proofing and Waterproofing Above Ground Level (D 201 – 25),
- High-Carbon Coal-Tar Pitch for Use in Constructing Built-Up Roofs, Surfaced with Slag or Gravel (D 251 – 27),

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[1] 1934 Supplement to Book of A.S.T.M. Standards, p. 127.

[2] 1933 Book of A.S.T.M. Standards, Part II, pp. 1019 to 1048.

High-Bitumen Coal-Tar Pitch for Use in Constructing Built-Up Roofs Surfaced with Slag or Gravel (D 252 – 27),
Asphalt for Use in Damp-proofing and Waterproofing Below Ground Level (D 40 – 25),
Asphalt for Use in Damp-proofing and Waterproofing Above Ground Level (D 144 – 25),
Creosote for Priming Coat with Coal-Tar Pitch in Damp-proofing and Waterproofing Below and Above Ground Level (D 43 – 25), and
Primer for Use with Asphalt in Damp-proofing and Waterproofing Below and Above Ground Level (D 41 – 26).

III. Editorial Revision of Tentative Standard.—It is recommended that the following minor changes be made in the Tentative Methods of Testing Emulsified Asphalt (D 244 – 35 T):[1]

Section 8 (e).—In the interest of accuracy the following revision is desirable: Change the last sentence to read as follows by the addition of the italicized words and figure:

> The end of the condenser to be inserted in the trap shall be ground off at an angle of 30 deg. ***plus or minus 5 deg.*** from the vertical axis of the condenser.

Section 8 (f).—To conform with the request of Committee E-1 on Methods of Testing in the standardization of apparatus and without in any way affecting the procedure or value of the test, it is proposed that this section be changed from its present form: namely,

> (*f*) ***Trap.***—The trap shall be made of well-annealed glass constructed in accordance with Fig. 3 (*c*) and shall be graduated from 0 to 25 ml. The tube shall be graduated from 0 to 2 ml. in 0.1 ml., from 2 to 5 ml. in 0.2 ml., and from 5 to 25 ml. in 0.5 ml. The outside diameters should be preferably 2.5 to 3.5 mm. ($\frac{3}{32}$ to $\frac{1}{8}$ in.) greater than the inside diameters specified.

to read as follows:

> (*f*) ***Trap.***—The trap shall be made of well-annealed glass constructed in accordance with Fig. 3 (*c*) and shall be graduated from 0 to 25 ml., in 0.1-ml. divisions. The tolerance of the graduations between 0 and 2 ml. shall be ± 0.5 ml. and between 2 and 25 ml. shall be ± 0.1 ml.

Fig. 3 (c).—Change the present illustration in Fig. 3 (*c*) to coincide with the revision of Section 8 (*f*).

IV. Tentative Standards Continued as Tentative.—Committee D-8 has the following two tentative standards which have been continued as tentative without revision since 1933: Tentative Methods of Testing Asphalt Roll-Roofing Surfaced with Fine Talc, Granular Talc or Mineral Granules, also Asphalt Shingles Surfaced with Mineral Granules (D 228 – 33 T), and Tentative Specifications for Asphalt Cap Sheet Surfaced with Mineral Granules (D 371 – 33 T). It is considered advisable to continue these as tentative as they are at present in process of revision.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 923 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 843.

The above recommendations have been submitted to letter ballot of the committee, which consists of 50 voting members, with the results shown in Table I.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee IV on Specifications (Including Analytical Methods) for Membrane Materials (E. H. Berger, chairman).—This subcommittee is working on revised methods for testing felted and woven fabrics for use in waterproofing and roofing. Samples have been prepared for this work and will be submitted to several members of the subcommittee for analysis in order to determine the adequacy of the present testing methods. Subcommittee IV would welcome suggestions from interested parties as to better methods for determining the saturation of felts and fabrics saturated with coal tar materials containing free carbon; also those saturated with coal tar and surfaced with talc, mica, or similar materials.

TABLE I.—ANALYSIS OF LETTER BALLOT VOTE.

Items	Affirmative	Negative	Not Voting
I. ADOPTION OF TENTATIVE STANDARD AS STANDARD			
Standard Abridged Volume Correction Table for Petroleum Oils (D 206 – 34), Group 0 and Group 1 tables	32	0	1
II. REVERSION OF STANDARDS TO TENTATIVE			
Specifications for High-Carbon Coal-Tar Pitch for Use in Damp-proofing and Waterproofing Below Ground Level (D 42 – 25)	29	0	3
Specifications for High-Carbon Coal-Tar Pitch for Use in Damp-proofing and Waterproofing Above Ground Level (D 145 – 25)	29	0	3
Specifications for High-Bitumen Coal-Tar Pitch for Use in Damp-proofing and Waterproofing Below Ground Level (D 200 – 25)	28	1	3
Specifications for High-Bitumen Coal-Tar Pitch for Use in Damp-proofing and Waterproofing Above Ground Level (D 201 – 25)	28	1	3
Specifications for High-Carbon Coal-Tar Pitch for Use in Constructing Built-Up Roofs Surfaced with Slag or Gravel (D 251 – 27)	29	0	3
Specifications for High-Bitumen Coal-Tar Pitch for Use in Constructing Built-Up Roofs Surfaced with Slag or Gravel (D 252 – 27)	29	0	3
Specifications for Asphalt for Use in Damp-proofing and Waterproofing Below Ground Level (D 40 – 25)	31	1	0
Specifications for Asphalt for Use in Damp-proofing and Waterproofing Above Ground Level (D 144 – 25)	31	1	0
Specifications for Creosote for Priming Coat with Coal-Tar Pitch in Damp-proofing and Waterproofing Below and Above Ground Level (D 43 – 25)	30	0	2
Specifications for Primer for Use with Asphalt in Damp-proofing and Waterproofing Below and Above Ground Level (D 41 – 26)	30	1	1

Subcommittee IV is studying the Standard Specifications D 42 – 25, D 145 – 25, D 200 – 25, D 201 – 25, D 251 – 27 and D 252 – 27 which cover high-carbon and high-bitumen coal tar pitch for waterproofing and roofing, and is cooperating with the Federal Specifications Board Committee on this project. An attempt is being made to prepare one specification for each use which will cover both high-carbon and high-bitumen pitches. To date, no data have been obtained by the subcommittee which would indicate superiority of one type over the other that would justify the Society retaining a separate specification for each type.

It is hoped that the above projects will have progressed so that definite revision can be recommended to Committee D-8 later in the year.

Subcommittee V on Specifications for Bituminous Coatings for Cold Application (E. O. Rhodes, chairman).—Subcommittee V is developing methods of test which will be suitable for the identification and evaluation of cold-application bituminous coatings employed for damp-proofing and waterproofing purposes. Since bituminous coatings of this kind are expected to damp-proof or waterproof the surfaces to which they are applied, waterproofness is of principal importance. For this reason the subcommittee feels that one or more tests for determining waterproofness should be selected or developed before consideration is given to methods of test required for identification purposes. Several methods for determining waterproofness have been considered and some of them are being tried. At the same time, consideration is being given to other tests needed to supplement the tests for waterproofness.

Subcommittee VIII on Accelerated Weathering Tests (O. G. Strieter, chairman).—This subcommittee is continuing its study of the Proposed Method for Accelerated Weathering Tests on Bituminous Materials.[1] Consideration is being given to certain refinements in the method, such as better controlled conditions of light, temperature and humidity.

Of interest in connection with the work of this committee are the studies to be described in a paper by O. G. Strieter on "The Effect of Mineral Fillers on the Serviceability of Coating Asphalts" to be presented at this annual meeting of the Society.[2]

Subcommittee XII on Tests for Mineral Surfacing Materials (H. W. Greider, chairman).—During the past year Subcommittee XII has prepared the following two proposed methods of test, appended hereto as information:

Proposed Method of Test for Sieve Analysis of Granular Mineral Surfacing for Asphalt Roofing and Shingles[3]

Proposed Method of Test for Sieve Analysis of Non-Granular Mineral Surfacing for Asphalt Roofing and Shingles[4]

It is expected that at the June meeting of Committee D-8 these two methods may be approved by the committee for reference to letter ballot, and if favorably acted upon by letter ballot subsequent to the meeting, will then be submitted to the Society through Committee E-10 on Standards for acceptance for publication as tentative.

Subcommittee XII has also completed a series of cooperative comparative tests with three different types of abrasion machines, designed to determine the effectiveness of embedding of granular mineral surfacing in the asphalt coating of the weather surface of asphalt prepared roofing and shingles. The results of this investigation will be of considerable interest to both producers and users of bituminous roofing and are published in a paper entitled, "A Comparison of Abrasion Test Methods for Embedding of Granular Mineral Surfacing on Asphalt Roofing," by H. W. Greider and G. A. Fasold, which appears as Appendix I to this report.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 381 (1933).

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 36, Part II, p. 486 (1936).

[3] See p. 461.

[4] See p. 464.

The election of officers for the ensuing term of two years resulted in the re-election of the present incumbents.

This report has been submitted to letter ballot of the committee which consists of 50 voting members; 33 members returned their ballots of whom 32 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

J. M. WEISS,
Chairman.

PRÉVOST HUBBARD,
Secretary.

APPENDIX I

A COMPARISON OF ABRASION TEST METHODS FOR EMBEDDING OF GRANULAR MINERAL SURFACING ON ASPHALT ROOFING

By H. W. Greider[1] and G. A. Fasold[1]

The subject of the adhesion of granular mineral surfacing materials to the asphalt coating of prepared roofing and shingles has, during the past few years, received increased attention from roofing technologists and roofing granule manufacturers, due in part to a clearer realization of the important role played by the mineral surfacing in protecting the coating asphalt and enhancing the durability of the roofing on weather exposure. With the advent, also, of new types of granules, synthetically colored to permit the manufacture of roofings of brighter and more attractive appearance, and making available a greater variety of color shades than can be had in natural slate and other rock granules, the subject assumed additional importance. Certain granules were found to embed less easily than natural slate granules and to require more care in handling on the roofing machine. The question also arose, whether the synthetic color treatment, coating or glaze, might in some cases make the adhesive bond between the granule and the coating asphalt less secure and permanent, thus permitting the granules to become detached from the coating after a period of weather exposure.

The need for more definite information on which to base the selection of suitable granular surfacing materials and to provide means for proper control of the embedding of the granular material in the manufacturing process has stimulated the development of various test procedures and devices intended to measure adhesion or perfection of embedding in the coating asphalt. Several of these test methods involve subjecting the granular surface of the finished roofing to abrasion in such a manner as to detach or abrade away the granules from the coating under specified test conditions, the loss of granules being determined by weighing. This report presents comparative data on three different abrasion test methods recently developed (two by granule producers and one by a roofing manufacturer) obtained in a cooperative study by Subcommittee XII on Tests for Mineral Surfacing Materials. These three methods do not include all the modifications of abrasion tests now in use, but are believed sufficiently representative of the principles involved to permit determining their practical usefulness and reliability of measuring the embedding of granules in coating asphalt.

The abrasion test machines used in the comparison were: (1) the Rub-Test Machine of the Minnesota Mining and Manufacturing Co., (2) the Rub-Test Machine of R. J. Funkhouser and Co., and (3) the Roofing Abrasion Test Apparatus of The Philip Carey Manufacturing Co. All tests were made in the Research Laboratory of The Philip Carey Manufacturing Co., on roofings especially produced by the Carey factory for the purpose of these comparative tests.

Description of Abrasion Test Devices:

1. *The Minnesota Mining Rub-Test Machine.*—This machine provides an abrasive or scrubbing action on the embedded granules by means of a standardized steel-

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[1] Director of Research, and Research Chemist, respectively, The Philip Carey Manufacturing Co., Lockland, Ohio.

wire brush actuated by a horizontally reciprocating crosshead driven by a motor with reduction gears. The brush is mounted on a floating head attached to the crosshead by ball-bearing toggles. The length of stroke of the brush is 6¾ in. and the load on the brush is approximately 4 lb. per sq. in. of its over-all area (1.25 sq. in.). The recommended test is 50 cycles (each of one forward and one backward stroke), weighing the specimens before and after the test to determine the granule loss. The machine is equipped with a starting device and counter which automatically stops the brush after 50 cycles.

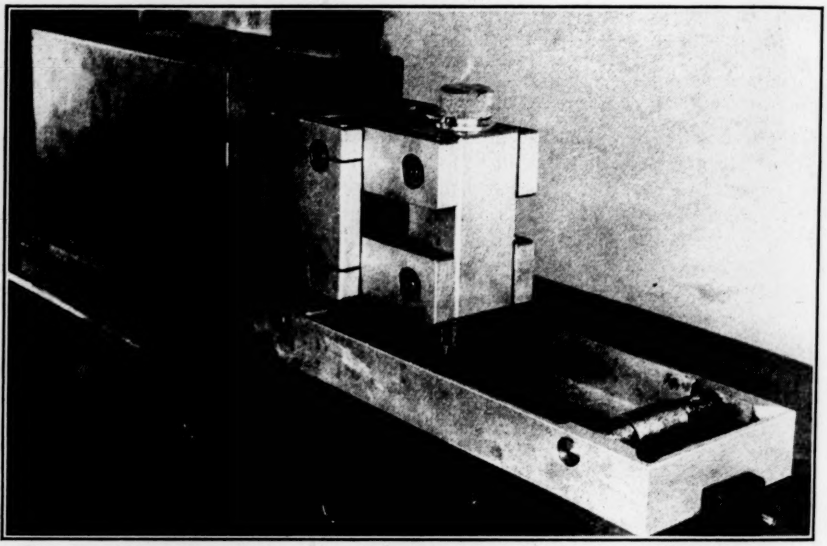


FIG. 1.—Minnesota Mining Rub-Test Machine, Showing Detail of Crosshead, Floating Head, Brush and Sample Holder.

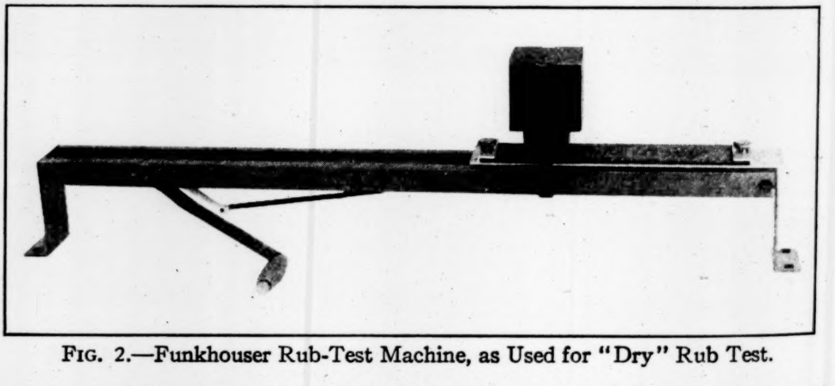


FIG. 2.—Funkhouser Rub-Test Machine, as Used for "Dry" Rub Test.

Figure 1 illustrates the complete machine, showing the floating head and brush lifted out of contact with the roofing test specimen. During an abrasion test the brush is dropped into contact with the specimen. The specimen holder is a cast aluminum-alloy pan, with built-in cam clamps, so that the specimen may, if desired, be kept immersed in water during the abrasion test. In making the "wet" test it is preferable to collect, dry and weigh the granules removed, rather than to attempt to dry and weigh the specimen.

2. *Funkhouser Rub-Test Machine.*—This machine also employs a steel-wire brush to abrade or pick the granules out of the coating, the length of stroke and pressure on the brush being approximately the same as in the Minnesota Mining apparatus. The Funkhouser machine is, however, of much simpler and less expensive construction, is hand operated instead of motor operated, and requires counting of the number of abrasive strokes, since it has no automatic stopping device. It also differs in that the specimen moves, and not the brush. The test may be run either "dry," as shown in Fig. 2 or, by using a pan may be run "wet," with the specimen immersed in water during the test. The recommended test is 50 cycles.

Both the Minnesota Mining and the Funkhouser Rub Tests require the use of a steel-wire brush of specified dimensions and wire characteristics. The useful life of the brush is limited, since after it becomes worn to such an extent that it will no longer duplicate the abrasion test results on a given specimen, as obtained with a new brush, it must be discarded.

3. *Carey Roofing Abrasion Test Apparatus.*—This is a simple device which permits the roofing sample itself to provide the abrasive action on the granular surfacing, by causing two pieces of the same sample to abrade each other in the same manner as when two pieces of sand paper are rubbed face to face. The apparatus consists of a channel having in the bottom a cut-out slot in which one piece of the roofing sample can be inserted and held without lateral movement. A rectangular brass block, weighing 7 lb. and having a similar cut-out in its lower face to act as a holder for the other piece of the sample, fits into the channel. A reciprocating sliding motion is imparted to the block by means of a hand lever or crank.

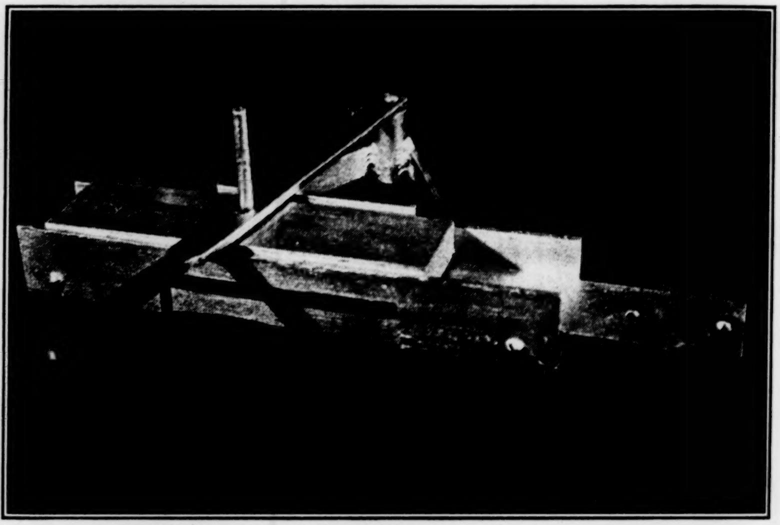
In making the test a 6 by 6-in. sample of the roofing is cut into two pieces, one 3½ by 6 in. and the other 2½ by 6 in., the larger piece being held in the channel and the smaller one held by the sliding block. The test consists of ten cycles (each of one forward and one backward stroke), the specimens being weighed before and after the test to determine granule loss. This apparatus may also be arranged for making the "wet" test with the specimens immersed in water, after the specimens have been soaked in water, in which case the granules removed are collected, dried and weighed directly. Figure 3 (*a*) illustrates the Carey Abrasion Test Apparatus, assembled with the specimens in place, as in making the test. Figure 3 (*b*) shows the separate parts and test specimens before assembly for the test.

This apparatus has the advantage of requiring no standardization or check testing of an abrading brush, since each sample tested provides its own, new, abrading surface. It has the disadvantage, with certain types of brittle or relatively soft mineral granules, of exerting an excessive grinding action on the granules themselves if the work required to break the granule is less than that required to detach it from the asphalt in which it is embedded.

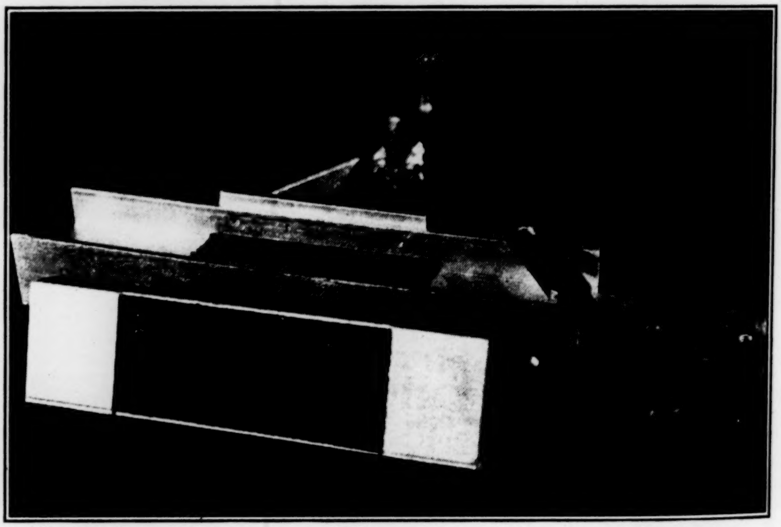
Types of Granules Included in Comparative Tests:

Five commercially used kinds of roofing granules were selected for this comparative test series, each different as to source, composition, shape, surface treatment and surface characteristics. The list included: (*a*) oiled, natural blue-black slate, extensively used by the roofing industry for many years and generally considered a very serviceable and permanent mineral surfacing, (*b*) natural gray-green slate, surface gum-treated, (*c*) crushed, fired shale, (*d*) slate base, synthetically colored with a silicate of soda glaze, fired at about 900 F. (480 C.), and (*e*) quartzite base, synthetically colored with a high temperature ceramic glaze, fired at about 1900 F. (1040 C.).

Not all varieties of commercial roofing granules are represented in the above list, but those included are considered typical of the more important kinds at present used in the industry.



(*a*) Assembled with specimen in place for test.



(*b*) Showing separate parts and test specimens before assembling for test.

FIG. 3.—Carey Roofing Abrasion Test Apparatus.

Asphalt Coating:

The asphalt coating used for the embedding of the granules was a commercial "shingle coating," having a softening point, ring-and-ball method, of approximately 230 F. (110 C.), produced by controlled oxidation (air blowing) of a blend of residues from the refining of Midcontinent petroleum. The coating contained about 25 per cent of inert mineral filler.

Manufacture of Roofing Samples:

The roofing samples used in the tests were all "standard weight" asphalt shingles, produced on a commercial roofing machine in the plant of The Philip Carey Manufacturing Co., Lockland, Ohio. These shingles conformed to all the requirements for Regular Weight Shingles, of A.S.T.M. Tentative Specifications for Asphalt Shingles Surfaced with Coarse Mineral Granules (D 225 - 35 T),[1] except for the mineral filler requirement under Section 5 (*i*). The amount and fineness of the mineral filler in the coating of these shingles was not within the limits of the above specifications. These shingles conformed to all the requirements of Underwriters' Laboratories for Class C label.

It had been planned to manufacture the shingles with the different kinds of granules all on the same day, thus keeping the felt, saturant, coating, and all manufacturing conditions as nearly uniform as possible and this was done except for those surfaced with silicated green slate granules.

With each kind of granule two different qualities of shingles were made: (*a*) shingles with the granules "well embedded," that is, meeting the standards of the Carey Factory Inspection Department in respect to granule loss, as determined by the Carey Abrasion Test Apparatus, but with no dark areas due to asphalt being pressed through between the granules; and (*b*) shingles with the granules "poorly embedded," that is, not meeting the above inspection standards, and from which a part of the granules could be easily detached by rubbing with the hand.

Selection of the Test Samples:

The shingles used in these tests were all taken near the center of a 72-in. wide sheet of roofing as run on the machine, and for each lot selected as to type and degree of embedding of the granules, all shingles were taken consecutively from the same band or strip of roofing material. Each lot contained approximately 100 shingles and from each lot 20 shingles were selected for test, these 20 being judged from appearance to be the most uniform, as to degree of embedding, in that particular lot. Ten of these shingles were used for the "dry" and 10 for the "wet" abrasion tests.

From each of the 10 selected shingles was cut (1) a 2 by 10-in. strip for the Minnesota Mining test, a 2 by 9-in. strip for the Funkhouser test, and a 6 by 6-in. strip for the Carey test; all strips were cut with the long dimension in the roofing machine direction. An extra set of 2 by 10-in. strips was cut from the ten shingles selected for the "wet" abrasion tests, to be used for the Minnesota Mining "wetted, then dried" modification of the "wet" abrasion test.

Method of Making the Abrasion Tests:

The 10 specimens for each test, from each lot, cut to size and numbered for identification, were weighed as a unit. Hence, no figures for deviation from the average of the abrasion test results of the individual test specimens can be given. The abrasion tests were then made with each machine, following the procedure recommended for each, and the ten specimens reweighed in the "dry" test, or the granules lost were collected on a No. 200 sieve, dried and weighed, in the "wet" test.

The "wet" test procedure was the same as for the "dry" test, except that the test strips were soaked in water at 70 to 80 F. (21 to 27 C.) before testing. In the Minnesota Mining and Funkhouser methods, the soaking period was 24 hr. and the sample was immersed during the abrasion test; in the Carey method, the soaking period was 2 hr., also with immersion while testing. A modification of the "wet" test suggested by the Minnesota Mining and Manufacturing Co. consisted of drying the specimens for 24 hr. at 70 to 80 F. (21 to 27 C.) after the 24-hr. soaking period, before testing, and the test results by this method are given under the heading "wetted, then dried."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 998 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 936.

To facilitate comparison all the granule loss figures given in Table I have been calculated to a uniform basis of 100 sq. in. of roofing surface subjected to abrasion. In calculating the actual abraded areas for the Minnesota Mining and Funkhouser methods, allowance was made for the unabraded areas between the end tufts of the rows of steel wire bristles, at each end of the brush stroke.

TABLE I.—ABRASION TESTS ON GRANULE-SURFACED ASPHALT ROOFING.

Granules			Granules Lost, g. per 100 sq. in.[a]						
			Minnesota Mining and Manufacturing Co. Method			R. J. Funkhouser and Co. Method		The Philip Carey Manufacturing Co. Method	
Kind	Color	Embedded	Dry	Wet	Wetted, then Dried	Dry	Wet	Dry	Wet
Ceramic (glazed quartzite)...	Green.........	Well......	2.48	2.12	1.94	3.38	2.29	8.0	8.0
		Poorly....	45.6	40.3	46.8	24.6	26.4	31.4	38.0
Natural slate (treated)......	Gray green....	Well......	4.10	2.05	3.23	4.58	3.62	8.0	9.7
		Poorly....	35.4	28.2	37.0	17.9	29.6	22.7	27.3
Slate, silicated.............	Green.........	Well......	2.37	6.57	1.72	1.93	6.27	4.3	20.0
		Poorly....	43.4	54.7	36.4	18.3	50.2	23.3	56.0
Fired shale.................	Red..........	Well......	2.26	5.73	3.44	2.66	4.82	6.7	9.0
		Poorly....	28.9	34.3	21.1	11.1	22.9	18.7	22.4
Natural slate (oiled).........	Blue black....	Well......	2.58	1.98	1.51	2.66	2.54	7.0	5.3
		Poorly....	16.7	22.7	22.7	7.48	16.4	16.3	21.0

[a] Granule loss in all three test methods calculated to 100 sq. in. of abraded area, for convenience of comparison. Actual abraded areas of the test specimens were as follows: Minnesota Mining method, 9.28 sq. in.; Funkhouser method, 8.27 sq. in. Carey method, 30 sq. in.

Discussion of Results:

Study of the data in Table I is quite convincing that any of the three test methods will definitely distinguish between granular surfacing which is "well embedded" and that which is "poorly embedded," *for the roofing, as manufactured.* Such abrasion tests do, therefore, have practical value for the control of the manufacture of granular surfaced roofing in that they permit the operator to determine whether the roofing being made has the granular surfacing mechanically well embedded, without relying merely on visual inspection. For each type of granule, however, the manufacturer must establish a maximum permissible granule loss figure for use by his inspection department, and this figure will be, necessarily, an arbitrary choice based on experience and judgment as to the proper limiting degree of embedding below which the granules are to be considered as "poorly embedded."

It is to be emphasized that abrasion tests cannot, for several reasons, be expected to predict accurately the permanence of adhesion of granules to asphalt coating when the roofing is exposed to the weather, except in so far as permanence of adhesion is influenced by the mechanical perfection of embedding of the granules. First, roofings are not usually, during weather exposure, subjected to abrasive forces approaching in degree of severity those to which the material is subjected in an accelerated abrasion test. Second, the character of the coating asphalt changes profoundly during weather exposure, particularly in respect to hardening and loss of plasticity, as a result of oxidation under the influences of moisture, high temperature, and actinic light. It seems certain that the surface adhesion relationships between the granule surface and the asphalt matrix also change as a result of the alteration in properties of the asphalt, as well as due to changes in the surface characteristics of the granule itself on weather exposure. However, an abrasion test can undoubtedly be used to advantage in studying these changes in adhesion between a particular type of granule and the coating, by subjecting a roofing surfaced with the granules to the abrasion test at intervals during a prolonged period of natural or accelerated weathering.

The abrasion test results by the Minnesota Mining method show, with all five types of granules tested, a greater numerical spread for the granule loss figures, between "poorly embedded" and "well embedded" mineral surfacing, than for either of the other methods; that is, the method is more sensitive to changes in the degree of embedding. The average results for all the types of granules, expressed as the ratio of granule loss, "poorly embedded" *versus* "well embedded" in the following condensed tabulation, show quite clearly that this is true, whether the test is made "wet" or "dry." However, further refinement of the Funkhouser and Carey devices to make them more sensitive seems quite feasible.

Regarding the relative merits of "dry" and "wet" abrasion methods of making the tests, the data indicate no particular advantage for the "wet" test or the "wetted then dried" test, where routine examination is being made of roofings surfaced with granules of known, satisfactory characteristics. In some cases the granule loss in the "wet" test method was no greater, or even less, than in the "dry" test. However, where a new type of granule is being considered, the "wet" test may give useful information regarding its characteristics and indicate whether its performance may be expected to be satisfactory. It will be noted, for example, that the "wet" method showed a higher granule loss than the "dry" method for the fired shale granule with all three abrasion machines. This was also true of the silicated slate granule to an even greater degree, for both "well embedded" and "poorly embedded" material.

Table II.—Ratio of Granule Loss—Poorly Embedded to Well Embedded.

Average for five types of granules.

Abrasion Test Method	Dry	Wet	Wetted, then Dried
Minnesota Mining and Manufacturing Co.	12.1	9.9	13.8
R. J. Funkhouser and Co.	5.3	7.5	....
The Philip Carey Manufacturing Co.	3.4	3.0	....

Conclusions:

Within the limitations necessarily imposed by the variety of types of granular mineral surfacing tested, by the characteristics of the asphalt coating of the roofing samples, by the particular types of abrasion testing apparatus used, and by the conditions under which the comparative tests were made, the following conclusions are believed justifiable:

1. Accelerated abrasion tests on granule surfaced roofing will readily distinguish between mechanically "well embedded" and "poorly embedded" mineral surfacing.
2. The value of such abrasion tests, as demonstrated to date, lies chiefly in their use as a means of control of the manufacturing of granule surfaced roofings. An abrasion method, such as the Carey test, which does not require a standardized brush or rechecking of the brush, has a distinct advantage for such control testing.
3. For routine testing of the perfection of embedding of granular mineral surfacing, the "wet" methods of test have no advantage over the "dry" method, but may be more indicative of the performance to be expected from granules of unknown characteristics.

4. The Minnesota Mining Rub Test method is more sensitive to differences in degree of embedding of the granules than either the Funkhouser or Carey test methods as shown by the greater numerical spread of the granule loss figures between "poorly embedded" and "well embedded" surfacing, or by the ratio of these two figures.

5. Accelerated abrasion tests may be found to give useful information regarding the adhesion of granules to coating if made on roofings which have been subjected to natural or accelerated weathering, rather than merely tested immediately after manufacture.

Acknowledgment:

The authors express their grateful appreciation to Mr. E. H. Nichols of R. J. Fundhouser and Co., and to Mr. L. A. Hatch of the Minnesota Mining and Manufacturing Co., for arranging the loan of their respective rub-test machines, for use in this cooperative investigation.

APPENDIX II

PROPOSED METHOD OF TEST
FOR
SIEVE ANALYSIS OF GRANULAR MINERAL SURFACING FOR ASPHALT ROOFING AND SHINGLES[1]

This is a **proposed method** and is published as information only. Comments are solicited and should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Scope

1. This method is intended for the sieve analysis of granular mineral surfacing material, such as crushed slate, stone, etc., used on the weather surface of prepared asphalt roofing and shingles.

Sieves

2. (*a*) A set of consecutive sieves of the series listed in Table I, conforming to the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E-11) of the American Society for Testing Materials,[2] shall be used. The group of sieves selected shall include those appropriate to the grading of the granular mineral to be subjected to sieve analysis; sieves of either the coarser or finer openings, on which less than 0.05 per cent of the weight of the sample of the particular material would be found after sieving, need not be included in the set.

TABLE I.—REQUIREMENTS FOR SIEVE OPENINGS AND WIRE DIAMETERS WITH PERMISSIBLE VARIATIONS.

Sieve Designation	Corresponding U. S. Standard Sieve Series Number	Sieve Opening		Wire Diameter		Tolerance in Average Opening, per cent	Tolerance on Wire Diameter, per cent		Tolerance in Maximum Opening, per cent
		mm.	in.	mm.	in.		Under	Over	
3360 micron	6	3.36	0.132	1.02	0.040	±3	15	30	10
2380 micron	8	2.38	0.0937	0.84	0.0331	±3	15	30	10
1680 micron	12	1.68	0.0661	0.69	0.0272	±3	15	30	10
1190 micron	16	1.19	0.0469	0.54	0.0213	±3	15	30	10
840 micron	20	0.84	0.0331	0.42	0.0165	±5	15	30	25
590 micron	30	0.59	0.0232	0.33	0.0130	±5	15	30	25
420 micron	40	0.42	0.0165	0.25	0.0098	±5	15	30	25
297 micron	50	0.297	0.0117	0.188	0.0074	±6	15	35	40
210 micron	70	0.210	0.0083	0.140	0.0055	±6	15	35	40
149 micron	100	0.149	0.0059	0.102	0.0040	±6	15	35	40

NOTE.—Sieves of the Tyler standard screen scale series, having mesh designations: Nos. 6, 8, 10, 14, 20, 28, 35, 48, 65 and 100, conform, respectively, to the requirements in Table I for sieve opening and wire diameter, within the tolerances stated, for the sieves of the U. S. Standard Sieve Series, in the order listed.

(*b*) Sieves shall be wire cloth, square-woven, from brass, bronze, or other suitable wire, mounted without distortion in circular frames, about 20 cm. (8 in.) in diameter and about 5 cm. (2 in.) between the top of the frame and the cloth.

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee D-8 on Bituminous Waterproofing and Roofing Materials.

[2] 1936 Book of A.S.T.M. Standards, Part II, p. 1413.

Sieve Shaker

3. A mechanically operated sieve shaker, which imparts to the set of sieves a rotary motion and tapping action of uniform speed, shall be used. The number of taps per minute shall be between 140 and 160.

Sample Splitter

4. A riffle sampler with $\frac{3}{8}$ or $\frac{1}{2}$-in. divisions, for reducing the gross sample to the quantity required for the sieve analysis, shall be used.

Unit for Sampling

5. Each carload of mineral granules shall be considered the unit for sampling, except that where a carload includes more than one kind of granular surfacing, the entire quantity of each kind in the car shall be considered the unit for each kind, respectively.

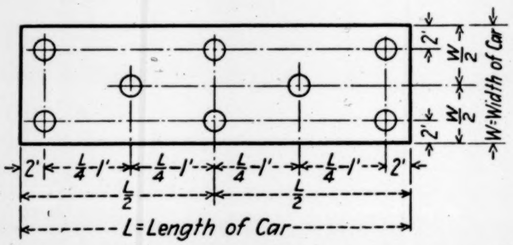

FIG. 1.—Location of Sampling Points from Surface of Car.

Gross Sample

6. (*a*) In collecting the gross sample from a carload of mineral granules shipped in bulk, eight equal increments of not less than 2 lb. each shall be taken from the material at the exposed surface of the car. A conical excavation about 1 ft. in depth shall be made at each sampling point and the sample taken from the bottom of the excavation. The eight sampling points shall be located as shown in Fig. 1.

(*b*) In collecting the gross sample from a carload of mineral granules shipped in bags, a number of bags shall be selected at random, equivalent to the cube root of the total number of bags in the car. The gross sample shall consist of equal increments of not less than 2 lb. from each of the bags taken for sampling.

(*c*) Where the mineral granules are being loaded or unloaded by conveyor or chute the gross sample shall preferably be collected by taking equal increments from the stream at regular time intervals, with such frequency that the total weight of the gross sample will be not less than 16 lb. Increments shall be taken from the full width and thickness of the stream, preferably, if practicable, by inserting a suitable container into the stream.

Reduction of Gross Sample

7. The gross sample shall be reduced by riffling or hand-quartering to not less than 500 g. (1.1 lb.).

Size of Test Sample

8. The entire sample obtained from reduction of the gross sample, shall be weighed with an accuracy of not less than 0.1 g., and taken for the sieve analysis.

Sieve Analysis

9. (*a*) The group of sieves selected from the series listed in Table I shall be assembled in consecutive order as to size of openings, with the sieve having the largest openings at the top and the one with the smallest openings at the bottom, the assembly being completed by a solid collecting pan below the bottom sieve. The test sample, previously weighed (Section 8), shall be placed on the top sieve and this sieve closed with a solid cover. The sieve assembly shall then be securely fastened in a suitable mechanical sieve shaking device (Section 3).

(*b*) The sample shall be passed through the sieves of the series selected, by subjecting it to the action of the sieve shaker for a period of 15 min. Since granular mineral surfacing materials usually have been subjected to grading by screens in the process of manufacture and hence separate rapidly into their sieve fractions, an end point determination is not considered necessary.

(*c*) The portion of the sample retained on each of the sieves and on the pan shall be carefully removed and weighed with an accuracy of not less than 0.1 g.

Report

10. The results of the sieve analysis shall be reported to the nearest 0.1 per cent (omitting the results on those sieves on which less than 0.05 per cent of the total weight of the test sample was collected), as follows:

	PER CENT
Retained on No. 6 (3360-micron) sieve....................................	....
Retained on No. 8 (2380-micron) sieve, passing No. 6 (3360-micron) sieve.......	....
Retained on No. 12 (1680-micron) sieve, passing No. 8 (2380-micron) sieve......	....
Retained on No. 16 (1190-micron) sieve, passing No. 12 (1680-micron) sieve.....	....
Retained on No. 20 (840-micron) sieve, passing No. 16 (1190-micron) sieve......	....
Retained on No. 30 (590-micron) sieve, passing No. 20 (840-micron) sieve.......	....
Retained on No. 40 (420-micron) sieve, passing No. 30 (590-micron) sieve.......	....
Retained on No. 50 (297-micron) sieve, passing No. 40 (420-micron) sieve.......	....
Retained on No. 70 (210-micron) sieve, passing No. 50 (297-micron) sieve.......	....
Retained on No. 100 (149-micron) sieve, passing No. 70 (210-micron) sieve......	....
Passing No. 100 (149-micron) sieve.....	....
Total....................................	....

Reproducibility of Results

11. Duplicate determinations by the same operator, using the same sieves, shall check within 1 per cent of the total weight of the sample, for the portion of the sample retained on each sieve and on the pan.

APPENDIX III

PROPOSED METHOD OF TEST
FOR
SIEVE ANALYSIS OF NON-GRANULAR MINERAL SURFACING FOR ASPHALT ROOFING AND SHINGLES[1]

This is a **proposed method** and is published as information only. Comments are solicited and should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Scope

1. This method is intended for the sieve analysis of non-granular mineral surfacing material, such as mica, talc and other powdered or flaky mineral particles, used on the weather surfaces of prepared asphalt roofing and on the non-weather-exposed surface of asphalt shingles.

Sieves

2. (*a*) A set of consecutive sieves of the series listed in Table I, conforming to the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E-11) of the American Society for Testing Materials,[2] shall be used. The group of sieves selected shall include those appropriate to the grading of the non-granular mineral to be subjected to sieve analysis; sieves of either the coarser or finer openings, on which less than 0.05 per cent of the weight of the sample of the particular material would be found after sieving, need not be included in the set.

TABLE I.—REQUIREMENTS FOR SIEVE OPENINGS AND WIRE DIAMETERS WITH PERMISSIBLE VARIATIONS.

Sieve Designation	Corresponding U. S. Standard Sieve Series Number	Sieve Opening		Wire Diameter		Tolerance in Average Opening, per cent	Tolerance on Wire Diameter, per cent		Tolerance in Maximum Opening, per cent
		mm.	in.	mm.	in.		Under	Over	
1680 micron	12	1.68	0.0661	0.69	0.0272	±3	15	30	10
1190 micron	16	1.19	0.0469	0.54	0.0213	±3	15	30	10
840 micron	20	0.84	0.0331	0.42	0.0165	±5	15	30	25
590 micron	30	0.59	0.0232	0.33	0.0130	±5	15	30	25
420 micron	40	0.42	0.0165	0.25	0.0098	±5	15	30	25
297 micron	50	0.297	0.0117	0.188	0.0074	±6	15	35	40
210 micron	70	0.210	0.0083	0.140	0.0055	±6	15	35	40
149 micron	100	0.149	0.0059	0.102	0.0040	±6	15	35	40
74 micron	200	0.074	0.0029	0.053	0.0021	±8	15	35	60

NOTE.—Sieves of the Tyler standard screen scale series, having mesh designations: Nos. 10, 14, 20, 28, 35, 48, 65, 100 and 200, conform, respectively, to the requirements in Table I for sieve opening and wire diameter, within the tolerances stated, for the sieves of the U. S. Standard Sieve Series, in the order listed.

(*b*) Sieves shall be wire cloth, square-woven, from brass, bronze, or other suitable wire, mounted without distortion in circular frames, about 20 cm. (8 in.) in diameter and about 5 cm. (2 in.) between the top of the frame and the cloth.

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee D-8 on Bituminous Waterproofing and Roofing Materials.

[2] 1936 Book of A.S.T.M. Standards, Part II, p. 1413.

Sieve Shaker

3. A mechanically operated sieve shaker, which imparts to the set of sieves a rotary motion and tapping action of uniform speed, shall be used. The number of taps per minute shall be between 140 and 160.

Sample Splitter

4. A riffle sampler with $\frac{3}{8}$ or $\frac{1}{2}$-in. divisions, for reducing the gross sample to the quantity required for the sieve analysis, shall be used.

Unit for Sampling

5. Each carload of non-granular mineral surfacing shall be considered the unit for sampling.

Gross Sample

6. In collecting the gross sample from a carload of non-granular mineral surfacing, a number of bags shall be selected at random, equivalent to the cube root of the total number of bags in the car. The gross sample shall consist of equal increments of not less than 0.5 lb. from each of the bags taken for sampling.

Reduction of Gross Sample

7. The gross sample shall be reduced by riffling or hand-quartering to not less than 100 g. (0.22 lb.).

Size of Test Sample

8. The entire sample obtained from reduction of the gross sample, shall be dried, weighed with an accuracy of not less than 0.1 g., and taken for the sieve analysis.

Sieve Analysis

9. (*a*) The group of sieves selected from the series listed in Table I shall be assembled in consecutive order as to size of openings, with the sieve having the largest openings at the top and the one with the smallest openings at the bottom, the assembly being completed by a solid collecting pan below the bottom sieve. The test sample, previously weighed (Section 8), shall be placed on the top sieve and this sieve closed with a solid cover. The sieve assembly shall then be securely fastened in a suitable mechanical sieve shaking device (Section 3).

(*b*) The sample shall be passed through the sieves of the series selected, by subjecting it to the action of the sieve shaker for a period of 20 min. At the end of this period the collecting pan, containing the portion of the material passing the finest sieve of the group selected, shall be removed from the sieve assembly and the contents weighed with an accuracy of not less than 0.1 g. The collecting pan shall then be re-assembled with the sieves, as before, and the shaking continued for an additional 10 min. At the end of this additional shaking period the collecting pan shall be removed and the contents weighed. If the additional material passing the finest sieve during this second shaking period does not exceed 0.5 per cent of the total weight of the sample, the sieve analysis shall be considered complete. If it does exceed 0.5 per cent, the collecting pan and sieves shall be re-assembled and shaken for successive additional 10-min. periods, weighing the material collected in the pan after each period of shaking, until the amount passing the finest sieve in a 10-min. shaking period is less than 0.5 per cent of the weight of the sample.

(*c*) The portion of the sample retained on each of the sieves and on the pan shall be carefully removed and weighed with an accuracy of not less than 0.1 g.

Report

10. The results of the sieve analysis shall be reported to the nearest 0.1 per cent (omitting the results on those sieves on which less than 0.05 per cent of the total weight of the test sample was collected), as follows:

	PER CENT
Retained on No. 12 (1680-micron) sieve	
Retained on No. 16 (1190-micron) sieve, passing No. 12 (1680-micron) sieve	
Retained on No. 20 (840-micron) sieve, passing No. 16 (1190-micron) sieve	
Retained on No. 30 (590-micron) sieve, passing No. 20 (840-micron) sieve	
Retained on No. 40 (420-micron) sieve, passing No. 30 (590-micron) sieve	
Retained on No. 50 (297-micron) sieve, passing No. 40 (420-micron) sieve	
Retained on No. 70 (210-micron) sieve, passing No. 50 (297-micron) sieve	
Retained on No. 100 (149-micron) sieve, passing No. 70 (210-micron) sieve	
Retained on No. 200 (74-micron) sieve, passing No. 100 (149-micron) sieve	
Passing No. 200 (74-micron) sieve	
Total	

Reproducibility of Results

11. Duplicate determinations by the same operator, using the same sieves, shall check within 1 per cent of the total weight of the sample, for the portion of the sample retained on each sieve and on the pan.

REPORT OF COMMITTEE D-9
ON
ELECTRICAL INSULATING MATERIALS

Committee D-9 on Electrical Insulating Materials held two meetings during the year and will hold a third during the annual meeting of the Society in June at Atlantic City, N. J. The meetings were held in November, 1935, and March, 1936, with an average attendance of 50 members and 29 visitors. At these meetings, considerable progress was made in the work which has been pending before the committee and several projects have reached the stage where definite recommendations were made resulting in additions or changes in the standards for which Committee D-9 is responsible. There are also a number of other projects still under way which are mentioned briefly later in this report.

RECOMMENDATIONS AFFECTING STANDARDS

As a result of the year's work, the committee is presenting one new tentative method of test, revisions of 10 tentative standards and is recommending the adoption as standard of one tentative standard and of one tentative revision of a standard. These are briefly detailed below together with the results of the letter ballot. The revisions being recommended are indicated in detail in the Appendix, each item being accompanied by a brief explanation of the reason for the proposed change of revision together with any data available to indicate the scope of investigation substantiating the recommendations.

I. Proposed Tentative Standard.—Upon the recommendation of Subcommittee IV on Insulating Mineral Oils, a modified Baader saponification test for electrical insulating oils has been published as information by Committee D-9 for the past two years.[1] Some constructive suggestions have been received and, as a result, the committee now recommends for publication as tentative the proposed Tentative Method of Test for Saponification Number of Electrical Insulating Oils (Modified Baader Method), as appended hereto.[2]

This method is suitable for determining the saponification number of used and unused electrical insulating oils, as well as other oils used in the electrical industry. The necessity for having a test for saponification number on used oils is because it furnishes useful information in determining the changes in oils resulting from oxidation. While the determination of neutralization number will give a relative measure of the acidity which has developed due to oxidation of the oil, the saponification number gives a most valuable check on the degree of aging, since this determination not only includes a measure of the acidic bodies but also of the neutral saponifiable materials which have formed. The changes reflected by these tests have an effect on the electrical conductivity of the oil and are also capable of destroying the insulation.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, p. 511 (1934).
[2] See p. 988.

It has also been shown that the development of saponifiable matter in insulating oils shows a fair parallelism with the change in dielectric constant. This was clearly indicated in the article on "Development of Polar Characteristics in Insulating Oils" by W. N. Stoops of the Research Laboratories of the Westinghouse Electric and Manufacturing Co., in the May, 1932, issue of *Physics*.

Numerous methods of test for saponification value were studied by the subcommittee, notably the A.S.T.M. Standard Method of Test for Saponification Number (D 94 – 28), and the classic method of Spitz and Hoenig, as well as the so-called Baader method which is the standard procedure adopted by the Association of German Electrical Engineers (VDE). Such modifications as have been made in the proposed method were in the interest of accuracy and application in general to the type of oils for which this test is recommended.

While this proposed method will furnish check results with the A.S.T.M. Standard Method D 94 on unused oils, marked differences occur in the application to used oils. These differences, which sometimes are in one direction and in other cases in the opposite, can partially at least be attributed to the difference in the indicators used, phenolphthalein being the standard indicator in Method D 94 and Alkali Blue 6-B in the proposed method. There is a difference in the pH values at which these indicators change colors. Phenolphthalein assumes a color at pH 10.0 whereas Alkali Blue 6-B assumes a pink color at pH 14.0. However, the blank determination in the proposed procedure will eliminate this factor. In such cases where the proposed method gives higher results, the increase may in part be attributed to the acid constituents of the oil. It was considered beyond the scope of this committee to examine more closely into the nature of the oxidation products formed in various oils, the primary object of the work being the development of a method of test which would furnish comparable results in different laboratories.

The advantages of this proposed method are:

1. Precision titrations are allowed in the use of 0.1 *N* solutions for digestion and titration.
2. Alkali Blue 6-B is more pronounced in color and has a sharper end point for colorimetric titration.

3. The error ordinarily risked with cork stoppers is obviated by the use of the mushroom type condenser.
4. The period of digestion is shorter.
5. Strength of acid and alkali minimizes the error introduced by the use of stronger solutions advocated in the present A.S.T.M. Standard Method D 94, particularly when the saponification value is low.
6. The color change of the Alkali Blue 6-B indicator is more readily discerned than that of phenolphthalein used in the present A.S.T.M. Standard Method D 94.

II. Proposed Tentative Revision of Standard.—The committee recommends for publication as tentative a revision of the Standard Methods of Testing Molded Materials Used for Electrical Insulation (D 48 – 33),[1] as given in the Appendix. This proposed change deals with requirements for impact test specimens and supplements the revisions[2] submitted through Committee E-10 on Standards in 1934.

III. Proposed Revision of Tentative Standards.—The committee is presenting revisions, as proposed in the Appendix, of the following nine tentative methods and one specification and recommends that, as revised, these tentative standards be continued as tentative:

Tentative Methods of:

Testing Varnishes Used for Electrical Insulation (D 115 – 35 T),[1]
Testing Electrical Insulating Materials for Power Factor and Dielectric Constant (D 150 – 35 T),
Testing Solid Filling and Treating Compounds Used for Electrical Insulation (D 176 – 35 T),
Testing Untreated Paper Used in Electrical Insulation (D 202 – 34 T),
Testing Sheet and Plate Materials Used in Electrical Insulation (D 229 – 35 T),
Test for Determining the Electrical Insulating Qualities of Slate (D 273 – 27 T),
Testing Varnished Cloths and Varnished Cloth Tapes Used in Electrical Insulation (D 295 – 34 T),
Test for Grading Natural Mica (D 351 – 35 T), and
Test for Thickness of Solid Electrical Insulation (D 374 – 34 T).

Tentative Specifications for:

Black Bias-Cut Varnished Cloth Tape Used for Electrical Insulation (D 373 – 34 T).

IV. Adoption of Tentative Standard as Standard.—The Tentative Methods of Testing Pasted Mica Used in Electrical Insulation (D 352 – 32 T)[3] have been available for the last three years. Committee D-9 is now recommending that these tentative methods be referred to letter ballot of the Society for adoption as standard. No criticism or suggested changes in the methods have been received since their publication as tentative and so far as can be ascertained by the committee they have proven satisfactory when used.

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[1] Subsequent to the annual meeting Committee D-9 presented to the Society additional revisions of these methods, see Editorial Note, p. 473.—ED.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, p. 1277 (1934); also 1934 Book of A.S.T.M. Tentative Standards, p. 1205.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 911 (1932); also 1935 Book of A.S.T.M. Tentative Standards, p. 1010.

V. Adoption of Tentative Revision of Standard as Standard.—As a tentative revision of the Standard Methods of Testing Electrical Insulating Oils (D 117 – 33), the committee presented last year[1] a new Section 9 of these methods which comprised a reference to the Standard Method of Test for Gravity of Petroleum and Petroleum Products by Means of the Hydrometer (D 287 – 33). The committee now proposes that this reference be incorporated in these standard methods and recommends that this revision be referred to letter ballot of the Society for adoption as standard.

TABLE I.—ANALYSIS OF LETTER BALLOT VOTE.

Items	Affirmative	Negative	Ballots Marked "Not Voting"
I. PROPOSED TENTATIVE STANDARD			
Test for Saponification Number of Electrical Insulating Oils	26	0	21
II. PROPOSED TENTATIVE REVISION OF STANDARD			
Methods of Testing Molded Materials Used for Electrical Insulation (D 48 – 33)	26	0	21
III. PROPOSED REVISIONS OF TENTATIVE STANDARDS			
Methods of Testing Electrical Insulating Material for Power Factor and Dielectric Constant (D 150 – 35 T)	37	1	9
Methods of Test for Determining the Electrical Insulating Qualities of Slate (D 273 – 27 T)	15	0	32
Methods of Testing Varnishes Used for Electrical Insulation (D 115 – 35 T)	27	0	20
Methods of Testing Solid Filling and Treating Compounds Used for Electrical Insulation (D 176 – 35 T)	20	1	26
Methods of Testing Untreated Paper Used in Electrical Insulation (D 202 – 34 T)	30	0	17
Methods of Testing Sheet and Plate Materials Used in Electrical Insulation (D 229 – 35 T)	26	0	21
Methods of Testing Varnished Cloths and Varnished Cloth Tapes Used in Electrical Insulation (D 295 – 34 T)	28	0	19
Methods of Test for Grading Natural Mica (D 351 – 35 T)	19	0	28
Methods of Test for Thickness of Solid Electrical Insulation (D 374 – 34 T)	29	0	18
Specifications for Black Bias-cut Varnished Cloth Tape Used for Electrical Insulation (D 373 – 34 T)	22	1	24
IV. ADOPTION OF TENTATIVE STANDARD AS STANDARD			
Methods of Testing Pasted Mica Used in Electrical Insulation (D 352 – 32 T)	20	0	27
V. ADOPTION OF TENTATIVE REVISION OF STANDARD AS STANDARD			
Methods of Testing Electrical Insulating Oils (D 117 – 33)	25	0	22

VI. Tentative Standards Continued as Tentative.—The Tentative Methods of Test for Comparing the Thermal Conductivities of Solid Electrical Insulating Materials (D 325 – 31 T) are not being recommended for adoption as standard although they have been tentative for four years. Through Subcommittee VII on Electrical Tests, measurements are being continued by those interested in these methods and it is recommended that they be continued as tentative until their adequacy is well determined.

The recommendations appearing in this report have been submitted to letter ballot of the committee which consists of 72 voting members; 47 members returned their ballots, with the results shown in Table I.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1403 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 1529.

ACTIVITIES OF SUBCOMMITTEES

A large part of the work of the subcommittees during the year has consisted in obtaining data and studying results with a view to improving the present standards and developing new standards. In any one year only a small portion of the work can result in definite recommendations as given in the first part of this report. It is felt desirable therefore to mention briefly some of the other projects which have engaged the attention of the subcommittees.

Subcommittee I on Insulating Varnishes, Paints and Lacquers (C. F. Hanson, chairman).—This subcommittee expects to have in the near future recommendations concerning the conditioning of samples in conducting tests for flow of shellac. The work on saturant varnish tests is being continued and the section dealing with acid and alkali resistance has been revised for further study.

Subcommittee II on Molded Insulating Materials (W. A. Evans, chairman).—A study to develop a standard method of measuring the degree of cure of phenolic molded materials is being made. A program for determining the effect of conditioning upon the properties of molded materials is being carried on. An effort is being made to standardize the molds used for making the standard test specimens in order to secure more uniform conditions.

Subcommittee III on Plates, Tubes and Rods (Dean Harvey, chairman).—This subcommittee has 2400 samples of sheet material ready to make comparison tests by different laboratories to determine the effect of conditioning upon impact strength, Rockwell hardness and power factor. An extensive study to determine methods of measuring the degree of cure of laminated phenolic products and to determine the best procedure to identify grades is under way in cooperation with the Navy Department. Methods of test for punching quality, heat resistance, and flammability of sheets are under consideration. A method of measuring the thickness of large sheets is being prepared at the request of the National Electrical Manufacturers Association.

Subcommittee IV on Insulating Mineral Oils (E. A. Snyder, chairman).—The paper by F. M. Clark and E. A. Snyder on "Testing for Sludge Formation in Mineral Transformer Oil,"[1] to be presented at this annual meeting of the Society, represents a summary of four years of work of Section B, of this subcommittee. Another subject engaging the active attention of Subcommittee IV is the selection of a suitable cell for power factor and resistivity measurements. This work is being carried on with the advice of Subcommittee VII on Electrical Tests. As part of the work, the members were canvassed to determine their preference as regards certain characteristics of the cell. The present preference seems to be for a cell of about 200-μF. capacity holding about 300 ml. of oil suitable for tests at about 3000 v. The cells should be capable of measuring accuracies of 0.0005 in power factor or better. A round-robin test series is also contemplated, utilizing the procedure for determining the gas content of oil, which has application to cable oils.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 36, Part II, p. 568 (1936).

Subcommittee IV, in cooperation with Committee D-2 on Petroleum Products and Lubricants, has completed the preparation of a Proposed Method of Test for Neutralization Number of Petroleum Products and Lubricants (Potentiometric Method). Since it is desired to have this method tried and commented on before taking any steps for adoption, it is being published[1] as information so that it may be available for trial by those interested.

Subcommittee V on Ceramic Products (*Porcelain, Glass, etc.*) (L. E. Barringer, chairman).—A review is being made of the application of the present Standard Methods of Testing Electrical Porcelain (D 116 – 34) to additional sizes of specimens. The section on glass is expected to have definite material for committee consideration within the coming year.

Subcommittee VI on Solid Filling and Treating Compound (M. F. Skinker, chairman).—Viscosity measurements are engaging considerable attention from this subcommittee. Several of the more recently developed types of viscosimeters are being considered. It is proposed in this regard to coordinate the efforts of Committee D-9 with the work of Committee D-2 on Petroleum Products and Lubricants.

Subcommittee VII on Electrical Tests (E. S. Lee, chairman).—As mentioned previously, this subcommittee is assisting Subcommittee IV on Insulating Mineral Oils in the development and the selection of a suitable cell in the resistivity and power factor measurements. A new method for resistivity measurements has been suggested which will assist in the difficulties which have always been present concerning surface or volume effects. A round-robin test series is also under way dealing with power factor measurements of liquid insulation. The results so far indicate that other factors than the cell are influential in determining the accuracies of the results. An inexpensive assembly has been suggested for power factor measurements of solid insulation. This may overcome difficulties which have been encountered in power factor measurements on mica. It is hoped that round-robin tests will permit early evaluation of this procedure. The assembly of equipment for power factor measurement of ultra-high frequencies is practically complete and results are expected in the near future.

Subcommittee VIII on Insulating Papers and Fabrics (*Treated and Untreated*) (R. W. Chadbourn, chairman).—The work on acidity of the

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[1] See p. 409.

Section on Paper of this subcommittee has reached the stage where it is felt that research needs to be undertaken before any further standard test procedure can be developed. The round-robin tests on oil penetration are now being studied. In connection with treated fabrics, the subcommittee will undertake to approach the A.S.T.M. Committee D-11 on Rubber Products with a view to approving a single type dielectric tester. There is also a program under way to coordinate the methods of the A.S.T.M. and the Insulated Power Cable Engineers Association for the step-by-step dielectric strength test. Extensive tests are being made to develop a standard method for power factor measurements of varnished cloth tape.

Subcommittee IX on Mica Products (M. P. Davis, chairman).—As mentioned previously a round-robin test series is in progress on power factor measurements of natural mica. Specifications for mica for insulation are also being discussed as the next work of this subcommittee.

Special Subcommittee on Conditioning (Robert Burns, chairman).—Progress is being made in unifying the conditioning requirements in the methods developed by Committee D-9. In addition this subcommittee is undertaking a study of oven equipment from which it is hoped, with the cooperation of the manufacturers, to develop a standard oven which will have broad application.

The election of officers resulted in the selection of the present incumbents for the ensuing term of two years.

This report has been submitted to letter ballot of the committee, which consists of 72 voting members; 47 members returned their ballots, of whom 44 have voted affirmatively, and 3 negatively.

Respectfully submitted on behalf of the committee,

T. SMITH TAYLOR,
Chairman.

E. J. RUTAN,
Secretary.

EDITORIAL NOTE

Subsequent to the annual meeting Committee D-9 on Electrical Insulating Materials presented to the Society through Committee E-10 on Standards the following additional recommendations:

Proposed Revision of Tentative Methods of:

Testing Varnishes Used for Electrical Insulation (D 115 – 36 T)

Testing Sheet, Tape, and Molded Insulating Materials for Dielectric Strength (D 149 – 34 T)

Proposed Tentative Revision of Standard Methods of:

Testing Molded Materials Used for Electrical Insulation (D 48 – 33)

The above recommendations were accepted by Committee E-10 on August 26, 1936. The tentative methods in their revised form and the tentative revision of the standard methods appear on pp. **1039**, **918** and **1204**, respectively.

APPENDIX

PROPOSED REVISIONS IN STANDARDS AND TENTATIVE STANDARDS FOR ELECTRICAL INSULATING MATERIALS

In this Appendix are given proposed revisions in certain standard and tentative standards covering electrical insulating materials which are referred to earlier in this report. In connection with each title is given the reference to the publication in which the standard appears in its present form.

Proposed Tentative Revision of Standard

Tentative Revision of Standard Methods of Testing Molded Materials Used for Electrical Insulation (A.S.T.M. Designation: D 48 – 33)[1]:

The following change in these standard methods is recommended for publication as a tentative revision:[2]

Section 14.—Add the following requirements for impact test specimens as Paragraph (*b*) of the new Section 14 on impact test proposed in 1934:

(*b*) *Test Specimens.*—Specimens for the Charpy test may be notched or unnotched as desired, according to conditions of service. The Izod test specimens shall be notched.

NOTE.—The unnotched specimen gives a higher strength than the notched specimen and the ratio of the strength of the unnotched specimen to that of the notched specimen varies with different materials.

Proposed Revisions of Tentative Standards

Revision of Tentative Methods of Testing Varnishes Used For Electrical Insulation (A.S.T.M. Designation: D 115 – 35 T)[3,4]:

This proposed revision comprises modifications in the present procedures for specific gravity and viscosity and also a revision of the section on calibration of suspensions in Appendix I of the methods. The present Section 2 on specific gravity is to be replaced by a test for density and the revised test for viscosity is to appear as Sections 3 to 6, inclusive, replacing the present Section 3. The section numbering for the remainder of the methods will of course need to be changed in accordance with these additional sections. These revisions, together with the changes in the present procedure for calibration of suspensions, are appended hereto.[1] The change of name from specific gravity to density is being made because the latter term is more definite whereas specific gravity requires the specification of the temperature of the water. The changes in procedure for both density and viscosity are being made so as to increase the precision.

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 1097.

[2] Subsequent to the annual meeting an additional revision of these standard methods was presented to Committee E-10 on Standards, see Editorial Note, p. 473. All of the pending tentative revisions of these methods appear on p. 1204.—ED.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1084 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 1104.

[4] Subsequent to the annual meeting additional revisions of these methods were presented to Committee E-10 on Standards, see Editorial Note, p. 473. The revisions have been incorporated in the revised tentative methods, see p. 1039.—ED.

Revision of Tentative Methods of Testing Electrical Insulating Materials for Power Factor and Dielectric Constant (A.S.T.M. Designation: D 150 – 35 T)[2]:

When these methods for measuring the power factor and dielectric constant of electrical insulating materials were originally written, they first included procedures for test at high frequency, then at intermediate frequency, and lastly at low frequency. These three procedures were later combined into the Tentative Methods D 150 – 35 T which has been in use during the past year. Further use and study of this method has led to what is considered to be an improved statement of procedure, which is more general and more fundamental and these changes and improvements have been incorporated in the completely revised methods appended hereto.[3]

Proposed Revision of Tentative Methods of Testing Solid Filling and Treating Compounds Used for Electrical Insulation (A.S.T.M. Designation: D 176 – 35 T)[4]:

This proposed revision comprises a new method useful for obtaining the density and coefficient of expansion of solid filling and treating compounds when they are in a liquid condition at high temperatures. It was not originally contemplated that it would be necessary to measure these qualities under such high temperatures. This new test, appended hereto,[5] is to be designated as Method *F* and headed "Plummet Displacement" and is to appear as Sections 28 to 32, inclusive. The section numbering for the remainder of the methods will of course need to be changed in accordance with the addition of these sections.

Revision of Tentative Methods of Testing Untreated Paper Used in Electrical Insulation (A.S.T.M. Designation: D 202 – 34 T)[6]:

The test for mil weight per ream of insulating paper is no longer in general use as a measure of apparent density so new methods of weight and apparent density have been developed and the committee recommends that these be substituted for the mil weight per ream method. A method for the determination of fiber composition is also being added, and minor editorial changes made elsewhere in these tentative methods. The detailed changes are as follows:

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[1] These changes have been incorporated in the revised tentative methods, see p. 1039.—ED.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol 35, Part I, p. 1044 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 1044.

[3] See p. 955.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1006 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 960.

[5] The tests for specific gravity and coefficient of expansion have been incorporated in the revised methods, see p. 1000.—ED.

[6] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, p. 1007 (1934); also 1935 Book of A.S.T.M. Tentative Standards, p. 1022.

Section 2 (c).—Change the first sentence of this section to read as follows by the omission of the word in brackets and the footnote.

The tests for acidity, moisture content, [size,] ash and for identification of fibers shall be made in duplicate upon portions taken from a composite sample.

Section 3.—Change the last sentence of this section to read as follows by the addition of the italicized word:

The following physical tests shall be made in the conditioned air: tensile breaking strength, tearing strength, bursting strength, folding endurance, air resistance, ***absorption,*** dielectric strength, and thickness.

Sections 33 to 36, inclusive.—Delete these sections covering the mil weight per ream method and add the following tests for weight and apparent density as new Sections 12 to 15, inclusive, renumbering the remaining sections accordingly:

12. ***Weight: Apparatus.***—The following apparatus will be required:

(*a*) ***Weighing Balance.***—A chemical balance or a specially-constructed sheet-weighing balance are necessary for the test. In case a chemical balance is to be used and if it is not in the conditioned atmosphere, a weighing bottle is also necessary. The weighing device shall be accurate to 0.25 per cent of the load applied.

(*b*) *Knife and Trimming Board.*—A sharp knife or accurate trimming board.

(*c*) *Scale.*—The scale used in measuring the specimen shall be capable of measuring to an accuracy of 0.25 per cent of the smallest dimension to be measured.

13. ***Specimens.***—Duplicate specimens shall be taken from as widely separated portions as possible from each of the samples obtained in accordance with Section 2 (*a*) and conditioned in accordance with Section 3.

14. ***Procedure.***—(*a*) Each specimen while in the conditioned atmosphere (see Section 3) shall be cut accurately to any convenient size and accurately weighed. Specimens of sufficient size to weigh at least from 3 to 5 g. (0.11 to 0.18 oz.) should be taken. If it is not possible to do the weighing in the conditioned atmosphere, the specimen shall be placed in a weighing bottle and tightly stoppered with a ground-glass stopper before being removed from the conditioned atmosphere.

(*b*) The weight shall be calculated to and expressed as grams per square meter.

NOTE.—Grams per square meter times 0.00142 equals pounds per 1000 sq. in., from which the weight in pounds per ream of any size can be calculated if desired.

15. ***Apparent Density.***—The apparent density shall be calculated from the thickness results obtained from the conditioned specimens as prescribed in Sections 8 to 11 and the weight determined in accordance with Sections 33 to 36, by means of the following formula:

$$\begin{array}{c}\text{Apparent Density}\\ \text{(grams per cubic centimeter)}\end{array} = \frac{\text{Weight (grams per square meter)}}{\text{Thickness, inches}} \times 0.0000394$$

New Section.—Add the following as a new Section 41, renumbering the remaining sections accordingly:

41. ***Fiber Composition.***—The percentage of various fibers contained in samples shall be determined in accordance with the Standard Methods of Analysis of Roofing Felt for Fiber Composition (A.S.T.M. Designation: D 272) of the American Society for Testing Materials.

Revision of Tentative Methods of Testing Sheet and Plate Materials Used in Electrical Insulation (A.S.T.M. Designation: D 229 – 35 T)[1]:

In order to get more reasonable Rockwell hardness numbers for the softer electrical insulating materials, the committee proposed certain modifications in the use of the scales and penetrators. These modifications were discussed with the Section on Indentation Hardness, of Committee E-1 on Methods of Testing in order to have a letter designation assigned for the combination of ¼-in. ball and 100-kg. load. That committee considered it desirable to use the red scale in order to restrict the black scale to the diamond penetrator. The use of the red scale would simply increase the present standard Rockwell values by 30 and would eliminate minus values for many of the softer materials covered by Committee D-9, particularly vulcanized fiber, and it was accordingly agreed upon. While it is true that the normal Rockwell hardness values for many grades of phenolic laminated fiber would run from 100 to 115, there seemed to be no particular objection to numbers over 100. The letter designation "M" has been assigned by Committee E-1. It is accordingly proposed that Method D 229 be revised as follows:

Section 41 (*b*).—Change from its present form: namely,

(*b*) The hardness shall be determined using a ¼-in. diameter ball penetrator, a minor load of 10 kg. and a major load of 100 kg., the readings being taken on the black figures.

to read as follows:

(*b*) The hardness shall be determined using a ¼-in. ball penetrator, a minor load of 10 kg. and a major load of 100 kg. The readings shall be taken on the red scale and shall be recorded as follows: Count the number of times the needle passes through zero on the red scale on the application of the major load. Subtract from this the number of times the needle passes through zero upon the removal of this load. If the difference is zero, the reading shall be recorded as over 100. If the difference is 1, the reading shall be recorded as between 0 and 100 and, if the difference is 2, the reading shall be recorded as negative.

Section 44 (*a*).—Change to read as follows by the addition of the italicized words and the omission of the word in brackets:

(*a*) The Rockwell hardness number read on the [black] *red* scale, the major load and the diameter of the penetrator. *The letter M shall precede the hardness number.*

Revision of Tentative Methods of Test for Determining the Electrical Insulating Qualities of Slate (A.S.T.M. Designation: D 273 – 27 T)[2]:

These methods were formerly under the joint jurisdiction of Committee D-9 and Committee D-16 on Slate, and with the discontinuation of the latter, Committee D-9 becomes solely responsible for these methods. The methods have been extensively improved and are appended hereto[3] in their completely revised form. The revised methods were evolved after considerable experimenting in several laboratories, including a round-robin test series using a method very similar to method *A* of the present Methods D 273 – 27 T. The new methods which are now recommended include two methods, *A* and *B*. The scope of each is indicated in the appended method. The new method *A* has been found by experiment on a number of samples to detect conducting veins with more certainty than the present Tentative Methods D 273 – 27 T, particularly when the veins come to the surface of the slate at very few points. It is also less hazardous to the operator and employs less expensive apparatus. The new method *B* is similar in principle to the methods given in D 273 – 27 T, but is more expeditious to use and employs more precise metering equipment.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1067 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 1067.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 27, Part I, p. 978 (1927); also 1935 Book of A.S.T.M. Tentative Standards, p. 1361.

[3] See p. 1021.

Revision of Tentative Methods of Testing Varnished Cloths and Varnished Cloth Tapes Used in Electrical Insulation (A.S.T.M. Designation: D 295 – 34 T)[1]:

The following minor changes in the section on dielectric strength test the chief of these being the addition of a paragraph on report, are recommended, the methods to be continued as tentative:

Section 15 (*b*).—Change to read as follows by the addition of the italicized words:

> (*b*) Dielectric strength tests may be applied to specimens of the material as received and on specimens from the elongation, resistance to oil *and heat* tests.

New Section.—Insert a new Section 17 to read as follows, renumbering the remaining sections accordingly:

> 17. *Report.*—The report shall include the following:
> (*a*) The method used for making the dielectric strength tests,
> (*b*) The average dielectric strength in volts per mil and any other values of dielectric strength as required by the materials specifications, and
> (*c*) The temperature at which the tests were made.

Revision of Tentative Methods of Test for Grading Natural Mica (A.S.T.M. Designation: D 351 – 35 T)[2]:

The following changes in the section on commercial quality of mica are recommended, the methods to be continued as tentative:

Section 5.—Omit the quality designated as "Black Stained or Spotted" and the note, which read as follows:

> *Black Stained or Spotted.*—Same as Stained but contains mineral inclusions.
>
> NOTE.—It is proposed to prepare a set of master standards complying with the above descriptions, from which sets of photographic prints or transparent autochrome plates can be furnished.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, p. 1074 (1934); also 1935 Book of A.S.T.M. Tentative Standards, p. 1092.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1035 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 1008.

substitute two new grades as follows:

Heavy Stained.—Free of mineral inclusions but contains more clay and vegetable stains than that of Stained and distinctly inferior as regards to rigidity and toughness.

Black Stained and Spotted.—Apt to contain some mineral inclusions consisting of magnetite (black), specularite (red), and hydrous iron oxide (yellow).

Revision of Tentative Methods of Test for Thickness of Solid Electrical Insulation (A.S.T.M. Designation: D 374 – 34 T)[1]:

The following minor changes are recommended in these thickness methods. The majority of the modifications have been requested by the instrument manufacturers so that unduly rigid specifications would not be imposed.

Section 2.—Change the first sentence to read as follows by the addition of the italicized words and the omission of those in brackets:

> The instrument used for determining thickness by Method A shall be a 1-in. machinist's type micrometer *without a locking device. It shall be* constructed with a vernier reading to 0.1 mil (0.0001 in.) and with a ratchet *or similar* mechanism [having a coil spring, pin-type pawl, and having] *for controlling measuring pressure, and shall have* anvil and spindle surfaces 0.250 in. ± 0.001 in. in diameter.

Section 4.—Change the first sentence to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

> The instrument used for determining [the] thickness by Method B shall be a 1-in. machinist's type micrometer [equipped] *without a locking device. It shall be constructed* with *a* vernier reading to 0.1 mil ([0.001] *0.0001* in.) [but without a ratchet device] and [shall have] *with* anvil and spindle surfaces 0.250 in. ± 0.001 in. in diameter.

Section 6.—Change Paragraph (*a*) of this section to read as follows by the addition of the italicized words:

> (*a*) Before and during instrument calibration and thickness measurements, the micrometer surfaces shall be maintained in a clean condition by lightly closing them on a clean sheet of *smooth* bond paper and moving the paper between the surfaces. *To minimize the danger of the presence of lint, the edge of the paper should not be pulled between the surfaces.*

Change Paragraph (*e*) of this section to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

> (*e*) The anvil and spindle surfaces of the micrometer shall be parallel to each other to [within] *less than* 0.0001 in. when tested with a pair of screw-thread-pitch wires [whose diameters] *or with a pair of ¼-in. nominal diameter plug gages. The diameters of the screw-thread-pitch wires or the plug gages,* accurate to 0.00002 in., *shall* differ by an amount approximately equal to the axial movement of the spindle when rotated through 180 deg. (12.5 mils [in the 1-in. micrometer]). The micrometer shall be closed on the wire*s or on the plug gages* according to the procedure described in Paragraph (*b*) or (*c*). Observations made with either wire *or with either plug gage* placed at any location between the surfaces shall show differences of less than 0.0001 in.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, p. 1069 (1934); also 1935 Book of A.S.T.M. Tentative Standards, p. 1087.

Add the following sentence at the end of Paragraph (*f*):

> The condition of zero reading is satisfied when examinations with a low-power magnifying glass shows that at least two-thirds of the widths of the zero graduation on the barrel and that of the reference mark coincide with each other.

Change the next to the last sentence of Paragraph (*h*) from its present form: namely,

> Three times the standard deviation for ten readings at each setting shall not exceed 0.1 mil (0.0001 in.).

to read as follows:

> At each value checked, ten readings shall be taken and the arithmetic mean of these ten readings shall not differ from the thickness of the gage used by more than 0.1 mil (0.0001 in.).

Revision of Tentative Specifications for Black Bias-cut Varnished Cloth Tape Used for Electrical Insulation (A.S.T.M. Designation: D 373 – 34 T)[1]:

Changes in the sections on thickness and dielectric strength tests of these methods are recommended, as given below. The thickness limits for tape have been re-expressed in inches instead of as a percentage because of the difficulty in measuring the percentages specified. As a result of the accumulation of considerable additional test data, it has also been possible to make more rigid the dielectric strength requirements without imposing any hardship upon the manufacturers.

Section 7.—Change the last sentence to read as follows by the addition of the italicized words and figures and the omission of those in brackets.

> The average thickness shall not vary more than ± [12 per cent] *0.001 in.* from the specified nominal thickness, and no individual measurement shall vary [by] more than [20 per cent] *plus 0.002 or minus 0.001 in. for tapes from 5 to 9 mils in thickness, nor more than plus or minus 0.003 in. for tapes 10 to 12 mils in thickness,* from the specified nominal thickness.

Section 15.—In Paragraph (*a*), change the values of dielectric strength "After Hot Oil" in Table I to agree with the "As Received" figures.

In Paragraph (*b*), change the deviation factor for uniformity within the roll from the present value of "0.11" to read "0.08."

In Paragraph (*c*), change the deviation factor for uniformity of the shipment from the present value of "0.10" to read "0.07."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, p. 959 (1934); also 1935 Book of A.S.T.M. Tentative Standards, p. 951.

REPORT OF COMMITTEE D-11
ON
RUBBER PRODUCTS

Committee D-11 on Rubber Products has held one meeting during the year in addition to the one held at the 1935 annual meeting. This was at Pittsburgh, Pa., on March 5, 1936, in connection with the spring group meetings of A.S.T.M. committees.

During the past year there have been a number of changes in the personnel of the committee. In this connection the committee wishes to record its deep regret at the resignation of Mr. C. B. Martin, occasioned by his retirement from active service. Mr. Martin has for many years been very closely associated with the work of the committee, having served more recently as chairman of Subcommittee V on Insulated Wire and Cable and in the past as secretary of the committee and as chairman of various other subcommittees. His work has contributed immeasurably to the progress of the committee. Mr. R. A. Schatzel succeeds Mr. Martin as chairman of Subcommittee V and Mr. A. R. Kemp has been appointed to replace Mr. Schatzel as chairman of Subcommittee XV on Life Tests. Mr. R. W. Chadbourn has been designated to succeed Mr. Martin as the Society's representative from Committee D-11 on the Sectional Committee on Insulated Wires and Cables, functioning under the procedure of the American Standards Association.

The committee is gratified at the increased interest in its work evidenced by the addition of the following new members: Messrs. G. S. Whitby, National Research Council of Canada; E. M. Paschall, Crescent Insulated Wire and Cable Co.; R. W. Carlson, Public Service Electric and Gas Co.; J. H. Ingmanson, Bell Telephone Laboratories, Inc.; L. V. Cooper, Firestone Tire and Rubber Co.; L. M. Freeman, The B. F. Goodrich Co. In addition, Mr. Alex Taub, the Chevrolet Motor Co., has been appointed to replace Mr. Frank C. McManus as the representative of the Society of Automotive Engineers on the committee; Mr. C. R. Troop, New York Central Railroad, to replace Mr. C. B. Martin as the representative of the Electrical Section of the Association of American Railroads, and Mr. E. H. Gibbs to replace Mr. C. A. Carlton, Seiberling Rubber Co. In addition to Mr. Martin, the committee has lost by resignation Mr. F. H. Amon, Godfrey L. Cabot, Inc., and Mr. Frank Kovacs, Barnwell and Co.

Subsequent to the 1935 annual meeting the committee presented to the Society through Committee E-10 on Standards three new tentative methods of test and revisions of two tentative specifications as follows:

Tentative Methods of:

Test for Accelerated Aging of Vulvanized Rubber (D 428 - 35 T)
Test for Adhesion of Vulcanized Rubber to Metal (D 429 - 35 T)
Test for Flexing of Rubber Products (D 430 - 35 T)

Revisions of Tentative Specifications for:

Insulated Wire and Cable: Class A0, 30 per cent Hevea Rubber Compound (D 27 - 35 T)
Insulated Wire and Cable: Performance Rubber Compound (D 353 - 35 T)

Details of the tests for accelerated aging and for flexing of rubber products were discussed in last year's annual report[1] of the committee. The test for adhesion of vulcanized rubber to metal was developed by the committee to fill a need for a method suitable for use with automotive parts and was based on the paper on the subject by Messrs. Flower and Wening which was appended to the 1934 report of the committee.[2] The additional revisions in the two specifications for insulated wire were based on action taken at the 1935 annual meeting and involved new tables of insulation resistance and test voltages. These new and revised tentative standards were accepted by Committee E-10[3] on September 28, 1935, and appear in the 1935 *Proceedings*.[4]

The volume of A.S.T.M. Standards on Rubber Products which was prepared by the committee to serve as a manual on methods of tests for rubber products was published by the Society in October, 1935, and has enjoyed very favorable comment. In addition to the standards, this pamphlet includes a useful bibliography giving sources of information concerning the properties and testing of rubber.

RECOMMENDATIONS AFFECTING STANDARDS

I. Revisions of Tentative Standards:

The committee is proposing revisions in one tentative specification and five tentative methods of test, as indicated below, and recommends that these tentative standards as revised be continued as tentative:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 426 (1935).

[2] A. H. Flower and H. E. Wening, "A Proposed Method for Testing the Adhesion of Rubber to Metal," *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, p. 525 (1934).

[3] In submitting these recommendations to Committee E-10 on Standards, Committee D-11 reported the following results of the letter ballot vote of a total of 39 ballots returned from a committee membership of 83; Methods D 428 - 35 T, affirmative 35, negative 0, ballots marked "not voting" 4; Method D 429 - 35 T, affirmative 30, negative 0, ballots marked "not voting" 9; Methods D 430 - 35 T, affirmative 32, negative 0, ballots marked "not voting" 7; Specifications D 27 - 35 T and D 353 - 35 T, affirmative 25, negative 0, ballots marked "not voting" 14.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, pp. 1167, 1180, 1186, 1115, 1141 (1935); also 1935 Book of A.S.T.M. Tentative Standards, pp. 1191, 1204, 1229, 1135, 1161.

Tentative Specifications and Tests for Friction Tape for General Use for Electrical Purposes (*D 69 – 35 T*).[1]—The following revision of the oven test is recommended:

Section 11.—Change Paragraph (*b*) to read as follows by the addition of the italicized words and the omission of those in brackets:

(*b*) Oven Test.—[After] A *tape* specimen [of tape has been] *similar to that described in Paragraph* (*a*) *shall be* exposed to dry air at a temperature of not less than 99 C. (210.2 F.) nor more than 101 C. (213.8 F.) for *a period of* 16 hr. [and] *The specimen shall be supported in the oven by means of clips or other suitable devices attached to the ends in such a way that the adhesion test portion, 19 in. in length, hangs free and not in contact with oven parts or other tape specimens.* After a rest period at room temperature of not less than 1 nor more than 12 hr., *during which the aged specimen shall be protected from contact with foreign material,* the [test] specimen shall withstand the test prescribed in Paragraph (*a*), except that the weight applied to unwind the tape shall be 3 lb. per inch of width in place of 4 lb. per inch of width.

Tentative Method of Test for Compression Set of Vulcanized Rub (*D 395 – 34 T*).[2]—The revisions proposed in this method include the addition of an alternative method for measuring compression set under constant deflection as discussed in the 1935 report of the committee. Also, the committee feels that both methods will be improved by the change which is recommended in the shape of the test specimen from a rectangular block to a cylindrical disk, as the latter shape provides more uniform stress distribution and flow conditions. These modifications have been incorporated in the tentative method which is appended hereto[3] in its completely revised form.

Tentative Methods of Tension Testing of Vulcanized Rubber (*D 412 – 35 T*).[4] The present form of the methods requires three specimens to be tested in all cases even though the purpose of the test may be merely to determine compliance with a definite minimum specified value. This necessitates useless work which it is proposed to eliminate. The revisions recommended are as follows:

Section 4.—Add the following as a new Paragraph (*f*):

(*f*) The testing machine shall be calibrated in accordance with the provisions of Section 6.

New Section.—Add the following as a new Section 6, renumbering the remaining sections accordingly:

6. *Calibration of Tension Testing Machines.*—Tension testing machines shall be calibrated by dead-weights applied in an ascending order while the machine is otherwise arranged in an entirely similar manner to that used when testing material. In each case when additional calibrating weight is added the weight lever of the machine

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1104 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 1124.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, p. 1164 (1934); also 1935 Book of A.S.T.M. Tentative Standards, p. 1210.

[3] See p. 1133

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1159 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 1183.

shall be moved to zero position and allowed to swing slowly upwards to the point where it will go no further. The dial of the machine should then clearly indicate the amount of the weight applied.

Section 11.—Renumber this section as Section 12 and change the first sentence of Paragraph (*a*) to read as follows by the addition of the italicized words:

12. (*a*) Three specimens per sample shall be tested for determinations of tensile strength, elongation, and stress-strain properties *except as noted in Paragraph* (*b*).

Add the following as a new Paragraph (*b*), relettering the present Paragraph (*b*) as (*c*):

(*b*) When minimum requirements are established as in testing for compliance with a particular specification, only one test shall be made for tensile strength, ultimate elongation or stress-strain relations. If the results are below the specified requirements, two additional specimens shall be prepared from the original sample and tested. Should the results of either of these tests be below the specified requirements, the sample shall be considered to have failed to meet the specifications.

Tentative Methods of Test for Adhesion of Vulcanized Rubber (*Friction Test*) (*D 413 - 35 T*).[1]—So that the adhesion test by the machine method may be applicable to both strip and ring specimens instead of only to strip specimens, as at present, the following revisions in these methods are recommended. These modifications are considered advisable in order to bring the methods into closer conformity with actual practice:

Section 2.—In Paragraph (*a*) under Ring Specimens, omit the last sentence which reads as follows:

Ring specimens shall be tested only by the dead-weight method.

Section 6.—Omit this section which reads as follows:

6. Only strip specimens shall be tested for adhesion by the machine method.

Section 7.—Add the following as a new Paragraph (*b*), relettering the subsequent paragraphs accordingly:

(*b*) Strip specimens shall be held in the testing machine by grips which clamp firmly and prevent slipping at all times during the test. For ring specimens the grip attached to the recording head of the machine shall be replaced with a freely rotating mandrel having an outside diameter substantially the same as the inside diameter of the ring which is placed on it. The mandrel shall be mounted in such a way that its axis of rotation will be in the plane of the ply being separated from the ring and that the applied force will be normal to the tangent of the ring circumference at the line of separation.

Change the present Paragraph (*c*) to read as follows by the addition of the italicized words:

(*c*) The rate of travel of the power-actuated grip shall be 2 in. per min. *for strip specimens and 1 in. per min. for ring specimens* uniformly throughout the test giving a rate of separation of 1 in. per min. *in both cases*.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1173 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 1197.

Section 8.—Add the following as a new Paragraph (*b*) on Ring Specimens, lettering the present section as Paragraph (*a*) on Strip Specimens:

(*b*) With ring specimens the layer of which the adhesion is to be tested shall be separated from the specimen by hand sufficiently to permit attaching the power-actuated clamp of the machine. The specimen shall be placed snugly on the test mandrel described in Section 7 (*b*). With the mandrel attached to the recording head of the machine and the separated layer gripped symmetrically and firmly without twisting in the power-actuated clamp, the autographic mechanism and chart shall be adjusted to zero and the machine started. The separating layer shall be stripped from the specimen approximately at an angle of 90 deg. to the tangent of the specimen surface and the separation continued for a sufficient distance to indicate the adhesion value. During the test, the mandrel shall rotate freely so as to maintain the line of separation at all times approximately in the same position.

Tentative Methods of Test for Accelerated Aging of Vulcanized Rubber (D 428 - 35 T).[1]—The following changes in these methods are recommended so as to eliminate unnecessary testing and to make the test work more convenient when minimum specified requirements are established:

Section 7.—Add the following as a new Paragraph (*b*), lettering the present section as Paragraph (*a*):

(*b*) When minimum requirements are established, one test shall be made for tensile strength and elongation. If the results are below the specified requirements, two additional specimens shall be prepared from the original sample and tested. Should the results of either of these tests be below the specified requirements, the sample shall be considered to have failed to meet the specifications.

Section 8.—Change the first sentence to read as follows by the addition of the italicized word and the omission of the word in brackets:

8. The stress-strain properties [including] *or* tensile strength and ultimate elongation of the original unaged specimens shall be determined within 24 hr. of the start of the aging period.

Add the following as a new Paragraph (*b*), lettering the present section as Paragraph (*a*):

(*b*) When rubber compounds are to be tested for the purpose of determining compliance with a specification, it shall be permissible to test the original properties required in Paragraph (*a*) simultaneously with the determination of the values after the first aging period even though the elapsed time exceeds 24 hr.

Section 10.—Change the first sentence to read as follows by the addition of the italicized words and the omission of those in brackets:

10. The tensile strength *and* ultimate elongation [and, if possible,] *or the* stress-strain properties of the specimens aged for different intervals shall be determined as the intervals terminate in the progress of the aging, disregarding the fact that more specimens may still be aging.

Tentative Method of Test for Adhesion of Vulcanized Rubber to Metal (D 429 - 35 T).[2]—The following revision in this method is recommended and is considered desirable since it states the condition of test specimen and does not restrict the manner of preparation to a single method as at present:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1167 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 1191.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1180 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 1204.

Section 6.—Change the second sentence of Paragraph (*a*) to read as follows by the addition of the italicized words and the omission of the word in brackets:

> The specimen shall be hollow-milled out of the production part and [turned] *the piece shall be finished either by turning or grinding* down to size *in such a manner that the surfaces of the rubber and metal shall be free from imperfections which would have any tendency to start a tear in the rubber part during the application of tension while testing.*

II. Revision of Standard:

The committee is presenting for immediate adoption as standard revisions in the Standard Methods of Chemical Analysis of Rubber Products (D 297 – 32).[1] The proposed modifications include a rearrangement of the methods in order to make them clearer and to avoid unnecessary repetition and duplication. A cautionary note has been inserted in the free sulfur determination for safety reasons; instructions for making the solution for use in the rubber solution method have been added in order to give more detail and make the method more complete, and a section has been added indicating the proper method to use for the determination of rubber hydrocarbon in hard rubber. Changes in the sulfur determinations have been made to provide for the use of picric acid as an aid to improved technique and accuracy. In view of the fact that these modifications do not involve any basic change in substance but will improve the usefulness, accuracy and safety of the present standard, it is requested that the revisions become effective immediately and, accordingly, the committee asks for the necessary nine-tenths vote at the annual meeting in order that the method in its revised form, as appended hereto,[2] may be referred to letter ballot of the Society for immediate adoption as standard.

III. Adoption of Tentative Standards as Standard:

The committee recommends that the following tentative standards be approved for reference to letter ballot of the Society for adoption as standard, without revision:

Tentative Methods of:

Testing Rubber Belting Used for Power Transmission (D 378 – 33 T)[3]
Testing Braided Hose (D 379 – 33 T)[3]
Testing Wrapped Rubber Hose (D 380 – 33 T)[3]

These methods have been published as tentative for three years and no serious criticisms nor unfavorable comments have been received concerning them. The Society has also been advised that these tentative methods have received the endorsement of the Specifications Committee of the Rubber Manufacturers Association.

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 1130.

[2] See 1936 Book of A.S.T.M. Standards, Part II, p. 1249.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, pp. 904, 909, 915 (1933); also 1935 Book of A.S.T.M Tentative Standards, pp. 1255, 1243, 1249.

IV. Tentative Standard Continued as Tentative:

Sufficient data are not yet available to warrant the change in the Tentative Specifications for Rubber Pump Valves (D 151 – 31 T) with respect to the method of measuring hardness, mentioned in last year's report. It is, therefore, desired that these specifications be continued as tentative for the present.

The recommendations appearing in this report have been submitted to letter ballot of the committee which consists of 83 members, the results being as follows:

Items	Affirmative	Negative	Ballots Marked "Not Voting"
I. REVISIONS OF TENTATIVE STANDARDS			
Specifications and Tests for Friction Tape for General Use for Electrical Purposes (D 69 – 35 T)	28	2	16
Method of Test for Compression Set of Vulcanized Rubber (D 395 – 34 T)	30	1	15
Methods of Tension Testing of Vulcanized Rubber (D 412 – 35 T):			
Revision of Section 4 and new Section 6	26	1	2
Revision of Section 11	39	0	7
Methods of Test for Adhesion of Vulcanized Rubber (Friction Test) (D 413 – 35 T)	33	0	13
Methods of Test for Accelerated Aging of Vulcanized Rubber (D 428 – 35 T)	39	2	5
Method of Test for Adhesion of Vulcanized Rubber to Metal (D 429 – 35 T)	30	0	16
II. REVISION OF STANDARD			
Methods of Chemical Analysis of Rubber Products (D 297 – 32), immediate adoption	39	2	5
III. ADOPTION OF TENTATIVE STANDARDS AS STANDARD			
Methods of Testing Rubber Belting Used for Power Transmission (D 378 – 33 T)	23	0	23
Methods of Testing Braided Hose (D 379 – 33 T)	24	0	22
Methods of Testing Wrapped Rubber Hose (D 380 – 33 T)	24	0	22

ACTIVITIES OF SUBCOMMITTEES

Nearly all of the subcommittees of Committee D-11 are actively engaged in carrying on various programs designed to keep the present A.S.T.M. standards on rubber products in agreement with best practice and to further the work of test development and standardization. Space limitations prevent detailed mention of all of these activities and therefore reference will be made only to several of the more important.

Advisory Committee (H. A. Depew, chairman).—A special section of the Advisory Committee has been working on a revision of the by-laws governing the activities of Committee D-11. This has been completed and the revised by-laws were approved at the spring meeting of the committee. They are, however, being referred to letter ballot vote of the entire committee for adoption.

Subcommittee V on Insulated Wire and Cable (R. A. Schatzel, chairman).—Subcommittee V decided to reorganize so as to carry on its work through two main sections in order to improve its effectiveness. To this end, the present sections on insulation resistant to acid, alkali and oil; corona-resistant rubber; saturants and finishes; and 60 per cent rubber sheath compound, were discontinued and replaced by new sections on (1) materials specifications and (2) test methods. Section 1 is to proceed at once to a consideration of revisions of the three existing Tentative Specifications for Insulated Wire and Cable: Class AO, 30 per cent Hevea Rubber Compound (D 27 – 35 T); Class A, 30 per cent Hevea Rubber Compound (D 393 – 34 T); and Performance Rubber Compound (D 353 – 35 T); and to the development of new specifications covering tough jacket compounds and possibly heat-resisting insulation. Section 2 will devote its attention at present to methods of test for high-voltage compounds, for moisture absorption and for thickness measurement of rubber and braid insulation. The subcommittee also decided to reconsider the present limitation to 5000 volts of Table IV on thickness of insulation and alternating test voltage in the Tentative Specifications D 27 – 35 T. It is anticipated that suggested changes will be presented for approval in the near future.[1]

Subcommittee XIV on Abrasion Tests for Rubber Products (G. S. Haslam, chairman).—The work being carried on by this subcommittee, in developing ways and means whereby standard rubber test specimens having certified and tested properties for use as a reference base in methods of testing rubber products can be made available, has progressed greatly during the year. An extensive program has been carried out in one laboratory. This program was designed to ascertain whether satisfactory uniformity and duplicability of such standards could be maintained and the results to date give much encouragement. The program has now been extended to include several laboratories and it is hoped in the near future that the subcommittee will be able to make definite recommendations in connection with this project.

Subcommittee XV on Life Tests for Rubber Products (A. R. Kemp, chairman).—This subcommittee has been making an extensive study of a method for testing the effect on rubber compounds of air at elevated pressure and temperature. This test, commonly known as the air bomb aging test, is assuming increasing importance for service evaluation of rubber compounds designed to resist heat and oxidation. It is particularly applicable and widely used for such products as inner tubes for truck tire service. A survey of the use being made of the test at the present time has been completed by the committee. The reports, which were received from 22 laboratories, indicated that the test is being employed in various forms by 18 of the laboratories. Because of the obvious importance of this method, it was decided to proceed at once with the preparation of a standardized procedure covering present practice and at the same time to initiate a program for extensive investigation of the test looking toward improvement and further standardization of the method. It is anticipated that the proposed method of test may be completed for submission to the Society, at least for publication as information, during the summer.

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[1] See Editorial Note, p. 489.—ED.

The election of officers resulted in the selection of the following for the ensuing term of two years:

Chairman, O. M. Hayden
Vice-Chairman, J. J. Allen
Secretary, Arthur W. Carpenter

This report has been submitted to letter ballot of the committee which consists of 83 members; 46 members returned their ballots, of whom 44 have voted affirmatively, and none negatively.

Respectfully submitted on behalf of the committee,

H. A. DEPEW,
Chairman.

ARTHUR W. CARPENTER,
Secretary.

EDITORIAL NOTE

Subsequent to the annual meeting Committee D-11 on Rubber Products presented to the Society on August 26, 1936, through Committee E-10 on Standards proposed revisions of the Tentative Specifications for Insulated Wire and Cable: Class AO, 30 per cent Hevea Rubber Compound (D 27 – 35 T) and for Insulated Wire and Cable: Performance Rubber Compound (D 353 – 35 T). The proposed revisions were accepted and the specifications in their revised form appear on pp. 1065 and 1092, respectively.

REPORT OF COMMITTEE D-13
ON
TEXTILE MATERIALS

Committee D-13 on Textile Materials has held two meetings during the year; the first was on October 17 and 18, 1935, at the Hotel New Yorker, New York City, and the second was on March 11, 12 and 13, 1936, at the Wardman Park Hotel, Washington, D. C. The number of members and guests registered at these meetings was 98 and 67, respectively. A third meeting will be held in June at Atlantic City, N. J., in conjunction with the annual meeting of the Society.

The Advisory Committee has approved the following changes in committee organization and chairmanships. In order to handle the work in the field of Subcommittee A-3, Section IV on Woolen and Worsted Fabrics more effectively, it has been decided to divide it between two sections, namely, Section IV on Pile Floor Coverings, and Section V on Woolen and Worsted Fabrics. Mr. A. G. Ashcroft continues as chairman of Section IV. Mr. F. A. Prisley has been appointed chairman of Section V. Subcommittee A-5 on Jute, Ramie and Linen is to be reorganized and designated Subcommittee A-5 on Bast Fibers and Their Products. The present Section I on Sugar Bags is discontinued as its usefulness is at an end. Mr. A. E. Davieau is in charge of the reorganization. In recognition of the rapidly developing interest in definitions, test methods and quality standards for textile materials which enter into certain types of ultimate consumer goods, the formation of a new Subcommittee A-6 on Household and Garment Fabrics has been authorized. Miss Ruth O'Brien has been appointed chairman. Mr. J. M. Weaver has resigned as chairman of Subcommittee A-4 on Asbestos and Its Textile Products, and Mr. H. A. Mereness as chairman of Subcommittee A-7 on Silk.

Mr. Werner Von Bergen represented the committee at a Trade Standard conference on the labeling of wool and part-wool fabrics conducted by the Division of Trade Standards of the National Bureau of Standards, and has been appointed on the standing committee set up by the conference. Due to the resignation of Mr. J. M. Weaver, Mr. F. S. Mapes is temporarily representing the interest of Committee D-13 upon the Sectional Committee on Electrical Insulating Materials, A. S. A. Project C59.

Committee D-13 records with regret the formal resignation of Mr. G. B. Haven from the Society after eighteen years of membership. Those years were marked by his deep interest in the affairs of Committee D-13 and with an unstinted contribution of time and work to the advancement of a fundamental technical knowledge of textiles and their testing. In view of this the committee has been pleased to place him on its roll as an honorary member.

Activity and interest in the work of the committee continues to grow. A symposium on Home Economics featured the fall meeting and one on Wool was presented at the spring meeting. The program of the latter meeting was extended over three days in order to reduce the number of conflicts between meetings of subcommittees having overlapping memberships. It is likely that three-day programs will be a permanent feature of future meetings. A canvass of the entire membership of Committee D-13 was made to get an up-to-date expression from each member as to the subcommittee on which he wished to serve. The result was an increase in the total subcommittee personnel.

The present membership of the committee is 171, of whom 68 are classified as producers, 51 as consumers, and 52 as general interest members.

Subsequent to the 1935 annual meeting, the committee presented to the Society through Committee E-10 on Standards the following two new tentative methods and revisions of two tentative methods. These were accepted for publication[1] by Committee E-10 at a meeting held on August 22, 1935, and appear in the 1935 *Proceedings:*[2]

New Tentative Methods of:

Testing Pile Floor Covering (D 418 – 35 T)
Testing Fineness of Wool (D 419 – 35 T)

Revisions of Tentative Methods of:

Testing and Tolerances for Woolen Yarns (D 403 – 35 T)
Testing and Tolerances for Worsted Yarns (D 404 – 35 T)

RECOMMENDATIONS AFFECTING STANDARDS

The recommendations of the committee regarding the standards and tentative standards under its jurisdiction are summarized below, together with the analysis of the letter ballot on each item. Comments, where necessary, are made under the Activities of Subcommittees.

I. *Proposed Tentative Standards.*—The committee recommends for publication as tentative the following four new methods of test, appended hereto:

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[1] In submitting these recommendations to Committee E-10 on Standards, Committee D-13 reported the following results of the letter ballot vote of a total of 45 ballots returned from a committee membership of 163: Methods D 418 – 35 T, affirmative 20, negative 0, ballots marked "not voting" 25; Methods D 419 – 35 T, affirmative 23, negative 0, ballots marked "not voting" 22; Methods D 403 – 35 T and D 404 – 35 T, affirmative 23, negative 1, ballots marked "not voting" 21.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, pp. 1229, 1256, 1263, 1268 (1935); also 1935 Book of A.S.T.M. Tentative Standards, pp. 1301, 1328, 1335, 1340.

Tentative Methods of Testing and Tolerances for Certain Carded Cotton Gray Goods,[1]
Tentative Method of Test for Resistance to Yarn Slippage in Silk, Rayon, and Silk-Rayon Woven Broad Goods,[2]
Tentative Method of Test for Fastness of Dyed or Printed Cotton Fabrics to Laundering or Domestic Washing,[3] and
Tentative Method of Test for Fastness of Dyed or Printed Silk or Rayon Fabrics to Laundering or Domestic Washing.[4]

II. *Proposed New Standard.*—The committee recommends that the method of test for shrinkage in laundering of woven cotton cloth, now appearing in Sections 14 to 21 of the Standard General Methods of Testing Woven Textile Fabrics (D 39 – 34), be issued as a separate standard under the title "Standard Method of Test for Shrinkage in Laundering of Woven Cotton Cloth."[5] This will involve no modification in substance of the standard method. It is accordingly recommended that the change be effected immediately and the committee accordingly asks for the necessary nine-tenths vote at the annual meeting in order that the method may be referred to letter ballot of the Society for immediate adoption as standard.

III. *Proposed Revisions of Tentative Standards.*—The committee is presenting revisions in the following tentative definitions and methods of test and recommends that, as revised, they be continued as tentative:

Tentative Definitions and Terms Relating to Textile Materials (D 123 – 35 T), revised as proposed in the Appendix,
Tentative Methods of Testing and Tolerances for Silk and Cotton Tapes (D 259 - 31 T), revised as proposed in the Appendix,
Tentative Methods of Test for Small Amounts of Copper and Manganese in Textiles (D 377 – 33 T), revised as appended hereto,[6] and
Tentative Methods of Testing Pile Floor Covering (D 418 – 35 T), revised as proposed in the Appendix.

IV. *Proposed Revisions of Standards.*—The committee is recommending revisions for immediate adoption in six standards, as follows:

Revisions in the following six standards are recommended to be made immediately and the committee accordingly asks for the necessary nine-tenths vote at the annual meeting in order that they may be referred to letter ballot of the Society for immediate adoption as standard.

Standard General Methods of Testing Woven Textile Fabrics (D 39 – 34) revised as appended hereto,[7]
Standard Methods of Testing and Tolerances for Cotton Yarns, Single and Plied (D 180 – 33), revised as appended hereto,[8]
Standard Methods of Testing and Tolerances for Cotton Sewing Threads (D 204 – 33), revised as appended hereto,[9]

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[1] See p. 1143.
[2] See p. 1157.
[3] See p. 1140.
[4] See p. 1154.
[5] See 1936 Book of A.S.T.M. Standards, Part II, p. 1344.
[6] See p. 1166.
[7] See 1936 Book of A.S.T.M. Standards, Part II, p. 1334.
[8] *Ibid.*, p. 1351.
[9] *Ibid.*, p. 1359.

Standard Specifications and Methods of Test for Asbestos Tape for Electrical Purposes (D 315 – 33), revised as appended hereto,[1]

Standard Specifications for 0.007-in. Cotton Tape for Electrical Purposes (D 335 – 34), revised as proposed in the Appendix, and

Standard Methods of Testing and Tolerances for Certain Light and Medium Cotton Fabrics (D 274 – 34), revised as appended hereto.[2]

V. *Adoption of Tentative Standards as Standard.*—The committee recommends that the following tentative standards be approved for reference to letter ballot of the Society for adoption as standard:

Tentative Method of Estimating Hard Scoured Wool in Wool in the Grease (D 232 – 35 T), without revision,

Tentative Methods of Testing and Tolerances for Tubular Sleeving and Braids (D 354 – 35 T), without revision,

Tentative Methods of Testing and Tolerances for Woolen Yarns (D 403 – 35 T), without revision,

Tentative Methods of Testing and Tolerances for Worsted Yarns (D 404 – 35 T), without revision,

Tentative Specifications for Textile Testing Machines (D 76 – 35 T), revised as proposed in the Appendix,

Tentative Specifications and Methods of Test for Asbestos Yarns (D 299 – 34 T), revised as appended hereto,[3] and

Tentative Specifications and Methods of Test for Asbestos Roving for Electrical Purposes (D 375 – 34 T), revised as appended hereto.[4]

VI. *Adoption of Tentative Revisions of Standards as Standard.*—The committee recommends that the tentative revision[5] of the Standard Methods of Testing and Tolerances for Hose Ducks and Belt Ducks (D 181 – 34) which has been standing for a year be approved for reference to letter ballot of the Society for adoption as standard.

VII. *Withdrawal of Standards.*—The committee recommends the withdrawal of the following standards:

Standard Methods of Testing and Tolerances for Electrical Cotton Yarns, Single and Plied (D 203 – 33),

Standard Specifications and Methods of Test for Asbestos Yarns (D 299 – 33), and

Standard Specifications for Textile Testing Machines (D 76 – 33).

The first has been combined with the revised Standard Methods of Testing and Tolerances for Cotton Yarns, Single and Plied (D 180 – 33) The second and third are being superseded by the revised tentative specifications on these subjects which are being recommended for adoption as standard.

VIII. *Tentative Standards and Revisions Continued.*—The committee recommends that all other tentative standards and tentative revisions of standards under its jurisdiction not specifically referred to under Activities of Subcommittees be continued as tentative for another year.

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 1324.

[2] *Ibid.*, p. 1365.

[3] *Ibid.*, p. 1320.

[4] *Ibid.*, p. 1317.

[5] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1406 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 1532.

The recommendations appearing in this report have been submitted to letter ballot of the committee, which consists of 171 members; 74 members have returned their ballots, with the results shown in the accompanying Table I.

Table I.—Analysis of Letter Ballot Vote.

Items	Affirmative	Negative	Ballots Marked "Not Voting"
I. Proposed Tentative Standards			
Methods of Testing and Tolerances for Certain Carded Cotton Gray Goods	83	0	41
Method of Test for Resistance to Yarn Slippage in Silk, Rayon, and Silk-Rayon Woven Broad Goods	27	0	47
Method of Test for Fastness of Dyed or Printed Cotton Fabrics to Laundering or Domestic Washing	32	0	42
Method of Test for Fastness of Dyed or Printed Silk or Rayon Fabrics to Laundering or Domestic Washing	30	0	44
II. Proposed New Standard			
Method of Test for Shrinkage in Laundering of Woven Cotton Cloth	32	0	42
III. Proposed Revisions of Tentative Standards			
Definitions and Terms Relating to Textile Materials (D 123 - 35 T)	57	0	17
Methods of Testing and Tolerances for Silk and Cotton Tapes (D 259 - 31 T)	26	0	48
Methods of Test for Small Amounts of Copper and Manganese in Textiles (D 377 - 33 T)	27	0	47
Methods of Testing Pile Floor Covering (D 418 - 35 T)	25	0	49
IV. Proposed Revisions of Standards			
General Methods of Testing Woven Textile Fabrics (D 39 - 34), immediate adoption	57	0	17
Methods of Testing and Tolerances for Cotton Yarns, Single and Plied (D 180 - 33), immediate adoption	50	1	23
Methods of Testing and Tolerances for Cotton Sewing Threads (D 204 - 33), immediate adoption	29	0	45
Specifications and Methods of Test for Asbestos Tape for Electrical Purposes (D 315 - 33), immediate adoption	21	1	52
Specifications for 0.007-in. Cotton Tape for Electrical Purposes (D 335 - 34), immediate adoption	24	0	50
Methods of Testing and Tolerances for Certain Light and Medium Cotton Fabrics (D 274 - 34), immediate adoption	42	0	32
V. Adoption of Tentative Standards as Standard			
Method of Estimating Hard Scoured Wool in Wool in the Grease (D 232 - 35 T)	23	0	51
Methods of Testing and Tolerances for Tubular Sleeving and Braids (D 354 - 35 T)	14	0	60
Methods of Testing and Tolerances for Woolen Yarns (D 403 - 35 T)	27	0	47
Methods of Testing and Tolerances for Worsted Yarns (D 404 - 35 T)	27	0	47
Specifications for Textile Testing Machines (D 76 - 35 T), as revised	50	0	24
Specifications and Methods of Test for Asbestos Yarns (D 299 - 34 T), as revised	23	0	51
Specifications and Methods of Test for Asbestos Roving for Electrical Purposes (D 375 - 34 T), as revised	21	1	52
VI. Adoption as Standard of Tentative Revision of Standard			
Standard Methods of Testing and Tolerances for Hose Ducks and Belt Ducks (D 181 - 34)	30	0	44
VII. Withdrawal of Standards			
Methods of Testing and Tolerances for Electrical Cotton Yarns, Single and Plied (D 203 - 33)	32	0	42
Specifications and Methods of Test for Asbestos Yarns (D 299 - 33)	30	0	44
Specifications for Textile Testing Machines (D 76 - 33)	51	0	23

ACTIVITIES OF SUBCOMMITTEES

Subcommittee A-1 on Cotton and Its Products (K. B. Cook, chairman):

Section I on Cotton (R. W. Webb, chairman).—This section has concentrated its efforts on stimulating interest in raw cotton. At the October meeting, two papers were read, as follows: "The New Coordinated Federal-State Cotton Research Program," by H. W. Barre, which outlined the important phases of the program; and "Formation and Microscopic Structure of Cellulose Membranes with Particular Reference to Cotton

Fibers," by Wanda K. Farr, which was a discussion of fiber structure in the light of recent information. At the March meeting, a Symposium on Cotton Ginning and Related Problems was held. The following papers were presented: "Problem Groups in Cotton Quality Research; Factors in Cotton Yarn and Fabric Quality," by R. W. Webb; "Some Mechanical Elements Involved in Cotton Ginning," by C. A. Bennett; "Some Cotton Quality Elements as Influenced by Ginning," by F. L. Gerdes; "Neps and Similar Imperfections in Cotton," by Norma L. Pearson. All the above authors are associated with the U. S. Department of Agriculture.

The section is reviewing its present Tentative General Methods of Test for Properties of Cotton Fibers (D 414 – 35 T) and is considering new and improved methods for measuring fiber properties.

Section II on Cotton Yarns and Threads (A. C. Clifford, chairman).—This section is presenting a revision, as appended hereto,[1] of the Standard Methods of Testing and Tolerances for Cotton Yarns, Single and Plied (D 180 – 33). This revision provides a standard covering general methods of testing cotton yarns and threads and makes unnecessary the Standard Methods of Testing and Tolerances for Electrical Cotton Yarns, Single and Plied (D 203 – 33), the withdrawal of which the section is recommending. A revision, as appended hereto,[2] of the Standard Methods of Testing and Tolerances for Cotton Sewing Threads (D 204 – 33) is being presented. This revision deletes those methods which appear in the proposed revised Standard Method D 180, mentioned above, and incorporates the revisions presented last year for publication as tentative. As the revisions are mainly of an editorial nature and in order that these two standards may appear in their revised form in the 1936 issue of the Book of Standards, the revisions are recommended for immediate adoption as standard.

The section is nearing the completion of its work on the development of a device for measuring yardage of thread or yarn in a package under uniform and controlled tension. Work on an "evenness" test for yarns and a "loop" test for lacings, sewing and tying threads, and twines will be undertaken.

Section III on Light and Medium Cotton Woven Fabrics (R. T. Fisher, chairman).—This section is presenting proposed Tentative Methods of Testing and Tolerances for Certain Carded Cotton Gray Goods, as appended hereto,[3] which agree in substance with specification G of the "Worth Street Rules, 1936" recently adopted by the majority of producers, distributors, and consumers of the goods covered by the proposed methods. The section is presenting for immediate adoption as standard an extensive revision, as appended hereto,[4] of the Standard Methods of Testing and

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[1] See 1936 Book of A.S.T.M. Standards, Part II, p. 1351.
[2] *Ibid.*, p. 1359.
[3] See p. 1143.
[4] See 1936 Book of A.S.T.M. Standards, Part II, p. 1365.

Tolerances for Certain Light and Medium Cotton Fabrics (D 274 – 34) which, through minor changes, brings it in line with the present classification of fabrics as set forth in the new methods proposed above.

This section is recommending, jointly with Section I on Methods, of Subcommittee B-1, that the test for shrinkage in laundering of woven cotton cloth now appearing as a part of the Standard General Methods of Testing Woven Textile Fabrics (D 39 – 34) be issued as a separate standard. This method is specifically applicable to cotton goods and is, therefore, out of place in a general standard. As the method is already a part of a standard, and in order to have it appear in the 1936 issue of the Book of Standards, the method, without change in substance, is recommended for immediate adoption as standard under the title "Standard Method of Test for Shrinkage in Laundering of Woven Cotton Cloth."

The section is planning a study of the methods for determining starch and the amount of natural waxes removed from the fiber by these methods.

Section IV on Tire Fabrics (Martin Castricum, chairman).—This section is actively engaged in cooperation with Section II on Machines, of Subcommittee B-1, in a study of calibration methods for testing machines. A thorough revision of existing standards relating to tire fabrics is being undertaken and consideration will be given to their possible combination into one standard.

Section V on Heavy Cotton Woven Fabrics (B. L. Whittier, chairman).—This section is recommending that the revision which has been standing as tentative for a year in the Standard Methods of Testing and Tolerances for Hose Ducks and Belt Ducks (D 181 – 34) be adopted as standard. A revision of the Standard Specifications for Tolerances for Numbered Cotton Ducks (D 230 – 27) will be undertaken to incorporate government tolerances for wide duck.

Section VI on Narrow Fabrics (F. S. Mapes, chairman).—This section is recommending that the Tentative Methods of Testing and Tolerances for Tubular Sleeving and Braids (D 354 – 35 T) be adopted as standard, no changes having been suggested. The section is recommending that the sections on marking and shipping of the Standard Specifications for 0.007-in. Cotton Tape for Electrical Purposes (D 335 – 34) be deleted as they more properly represent contractural matters. The section is presenting for publication tentative revisions, as given in the Appendix, of the Tentative Methods of Testing and Tolerances for Silk and Cotton Tapes (D 259 – 31 T) to enlarge its scope, modify the tolerances and method of measurement for thickness, and provide a method for determination of sizing content.

Subcommittee A-2 on Rayon and Its Products (A. M. Tenney, chairman):

This subcommittee is cooperating with Subcommittee B-6 on Papers in the development of plans for a Symposium on Rayon at the October, 1936, meeting.

Section I on Rayon (A. M. Tenney, chairman).—This section has been studying the Tentative Methods of Testing and Tolerances for Rayon (D 258 – 35 T) which underwent an extensive revision last year, with a view to simplification. Several editorial changes will be offered for incorporation in the next printing of the methods.

Section II on Rayon Fabrics (Alexis Sommaripa, chairman).—This section has cooperated with Subcommittee A-7 on Silk in the development of a method for testing yarn slippage. The section has taken an active part in the conferences leading up to the adoption of the Recommended Commercial Standard for Woven Dress Fabrics—Testing and Reporting sponsored by the Division of Trade Standards of the National Bureau of Standards. The section is planning work on performance tests for unraveling and fraying of rayon fabrics.

Subcommittee A-3 on Wool and Its Products (G. E. Hopkins, chairman):

Section I on Wool (Werner Von Bergen, chairman).—This section is recommending that the Tentative Method of Estimating Hard Scoured Wool in Wool in the Grease (D 232 – 35 T) be adopted as standard. The method has shown satisfactory results in use and no adverse criticisms have been made. The section is carrying out interlaboratory checks on the cross-section and wedge methods of measuring the diameter of wool fibers, studying methods for identifying special hair fibers in mixtures with wool, considering specifications for wool top standards and cooperating with the American Association of Textile Chemists and Colorists on methods of extraction to determine oil and grease content.

Section II on Felt (J. F. Marshall, chairman).—This section has been engaged in the development of methods of testing felt. Interlaboratory check tests are being made and it is expected that the methods will be presented for publication as tentative as soon as the tests are completed.

Section III on Woolen and Worsted Yarns (Fred Noechel, chairman).—This section is recommending that the Tentative Methods of Testing and Tolerances for Woolen Yarns (D 403 – 35 T), and for Worsted Yarns (D 404 – 35 T) be adopted as standard. No criticism of these two tentative methods has been received. The section is gathering data to establish tolerances for variation in single tests as well as tolerances for average results, and is cooperating with the American Association of Textile Chemists and Colorists on methods for quantitative analysis of mixtures of cotton and rayon with wool.

Section IV on Woolen and Worsted Fabrics (A. G. Ashcroft, chairman).—This section is presenting for publication tentative revisions, as given in the Appendix, of the Tentative Methods of Testing Pile Floor Covering (D 418 – 35 T) as an improvement in the method for measuring back thickness. The section is working on additional test methods for pile floor covering, including wear tests, chemical tests, stiffening materials and adhesives, fading tests, and specifications and methods of test for woolen and worsted fabrics.

Subcommittee A-4 on Asbestos and Its Textile Products:

Section I on Asbestos Textiles (W. H. Whitcomb, temporary chairman).—This section is presenting revisions, as appended hereto,[1] of the Tentative Specifications and Methods of Test for Asbestos Yarns (D 299 - 34 T), and for Asbestos Roving for Electrical Purposes (D 375 - 34 T). These revisions cover changes which have been found in practice to be desirable. The section recommends that these two specifications be adopted as standard as revised. The section is presenting for immediate adoption a revision of the Standard Specifications and Methods of Test for Asbestos Tape for Electrical Purposes (D 315 - 33), as appended hereto.[2] The revision covers changes which have been found in practice to be desirable.

Subcommittee A-7 on Silk (H. A. Mereness, chairman):

Subcommittee A-7 is presenting a proposed Tentative Method of Test for Resistance to Slippage in Silk, Rayon and Silk-Rayon Woven Broad Goods, as appended hereto,[3] which was printed as information only in the 1935 issue of the volume of A.S.T.M. Standards on Textile Materials. The proposed method has been in use for some time and has been subject to a critical review during the past year. Section II on Rayon Fabrics, of Subcommittee A-2, has collaborated in the development and study of the method.

Subcommittee B-1 on Methods and Machines (W. D. Appel, chairman):

Section I on Methods (W. D. Appel, chairman).—This section is presenting a revision, as appended hereto,[4] of the Standard General Methods of Testing Woven Textile Fabrics (D 39 - 34). This revision is largely editorial in character with some changes in substance to bring it into agreement with present practice. The revisions which have previously been accepted for publication as tentative have been incorporated. In order that these methods may appear, in their revised form, in the 1936 issue of the Book of Standards, the revision is recommended for immediate adoption as standard.

The section is working on methods for determination of sizing (in collaboration with Section III of Subcommittee A-1) and on chemical methods for analysis of cotton-wool mixtures. The section is planning work on microscopic methods for the quantitative analysis of fiber mixtures that cannot be analyzed by chemical or mechanical procedures.

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[1] See 1936 Book of A.S.T.M. Standards, Part II, pp. 1320 and 1317.
[2] *Ibid.*, p. 1324.
[3] See p. 1157.
[4] See 1936 Book of A.S.T.M. Standards, Part II, p. 1334.

Section II on Machines (H. J. Ball, chairman).—This section is recommending revisions in the Tentative Specifications for Textile Testing Machines (D 76 – 35 T), as proposed in the Appendix, which consist of a modification of the requirements for single strand jaws and the incorporation of specifications for a thickness gage. The latter is a revised form of the requirements appearing in the Standard General Methods of Testing Woven Textile Fabrics (D 39 – 34) from which they are being deleted. The revised specifications will supersede the Standard Specifications for Textile Testing Machines (D 76 – 33) which are accordingly being withdrawn.

Two papers were read before the section, as follows: "Calibration of Inclined Plane Serigraph," by R. S. Cleveland, which presented methods employing the use of dead weights over a pulley or of calibrating springs; and "Calibration of a Horizontal Form of Dead Weight Lever or Pendulum Type of Testing Machine," by D. C. Scott, which presented calibration data by proving ring and dead weight methods, indicating the superiority of the latter.

The section will study the flatness and parallelism of jaws with a view to setting tolerances, the rate of loading of the incline plane type of testing machine, calibration methods for testing machines, and is continuing its work on specifications for diaphragm bursting testers.

Section III on Humidity (R. H. Brown, chairman).—This section has been active in considering the many phases of its work. Methods of conditioning samples before testing are being studied. Data on regains of specific material are being accumulated. Much of the work of this section is for the benefit of the committee as a whole in providing data for the more exact formulation of conditions in methods of testing the various materials.

The section is planning a Symposium on Humidity at the March, 1937, meeting.

Subcommittee B-2 on Nomenclature and Definitions (A. L. Brassell, chairman):

This subcommittee recommends a revision, as given in the Appendix of the Tentative Definitions and Terms Relating to Textile Materials (D 123 – 35 T). Considerable difficulty is being experienced in separating the terms in the above-mentioned standard into two lists as referred to in the 1934 report of the committee but is continuing its work on the plan. The section is planning work on standard definitions for fabrics; and a standard method of expressing fabric weight.

Subcommittee B-4 on Bleaching, Dyeing and Finishing (W. M. Scott, chairman):

This subcommittee is presenting two proposed tentative methods. Method of Test for Fastness of Dyed or Printed Cotton Fabrics to Laundering or Domestic Washing, and Method of Test for Fastness of Dyed or Printed Silk or Rayon Fabrics to Laundering or Domestic Washing, as appended hereto.[1] The first is a revised form of the method of the same title printed in the 1935 issue of the volume of A.S.T.M. Standards on Textile Materials. The second is a similar method for silk or rayon fabrics. Both methods are substantially the same as those appearing in the Commercial Standard for Woven Dress Fabrics—Testing and Reporting, sponsored by the Division of Trade Standards of the National Bureau of Standards. The subcommittee recommends a revision of the Tentative Methods of Test for Small Amounts of Copper and Manganese in Textiles (D 377 – 33 T), as appended hereto,[2] which is principally the addition of a colorimetric method for copper. The subcommittee reports that work on the detergency of soaps has been postponed pending the outcome of the proposal that the Society organize a new committee to cover this field. Work will be continued upon a test for the fastness of dyed fabrics to light and it is planned to develop test methods and specifications for textile chemicals.

Subcommittee B-5 on Sampling, Presentation and Interpretation of Data (A. G. Ashcroft, chairman):

This subcommittee has been active in its educational program, particularly along the lines of presentation and interpretation of data. The increased use of the statistical approach in subcommittee work is evidenced by the treatment of data in a paper by Mr. Werner Von Bergen (see Subcommittee B-6 on Papers); a discussion of moisture equilibrium by Mr. C. M. Conrad before Section II on Humidity, of Subcommittee B-1: a report of interlaboratory tests on tensile strength of heavy cotton fabrics before Section IV on Tire Fabrics, of Subcommittee A-1; and a report on thickness measurements on pile floor covering before Section IV on Woolen and Worsted Fabrics, of Subcommittee A-3. The subcommittee has prepared, for publication in the 1936 edition of the volume of A.S.T.M. Standards on Textile Materials, a statement making suitable reference to the A.S.T.M. Manual on Presentation of Data and an illustrative example of the application of statistical methods. A general paper on statistical methods will be presented at the October meeting.

Subcommittee B-6 on Papers (Dean Harvey, chairman):

This subcommittee arranged for the presentation of the following papers at the interim meetings of Committee D-13:

"How Can Results of Fading Tests Be Expressed?" by Dorothy Nickerson;

"Some Recent Studies of Aging of Weighted and Unweighted Silk," by Pauline Beery Mack;

"More Work for D–13—Standard Test Methods Needed for Consumer Fabrics," by Ruth O'Brien;

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[1] See pp. 1140 and 1154.

[2] See p. 1166.

"Results on Questionnaire on Textile Test Methods Needed by Teachers of Home Economics," by H. J. Ball;
"Serviceability Tests on Fall and Winter Dress Fabrics," by Dorothy Saville and Ethelwyn Dodson;
"Buying Raw Wool on the Scientific Basis," by Werner Von Bergen;
"Development of Scientific Methods Applicable to the Production of Wool," by J. I. Hardy;
"Sizing and Finishing of Textile Fabrics," by F. G. La Piana, and
"Wearability of Silk Dresses," by Mary C. Whitlock.

Arrangements were also made for the presentation of a motion picture of the hosiery testing machine developed by the National Bureau of Standards. Abstracts of the above papers are being prepared for publication in the 1936 issue of the volume of A.S.T.M. Standards on Textile Materials. The subcommittee is planning a Symposium on Rayon for October, 1936, and a Symposium on Humidity for March, 1937.

The following officers were elected for the two-year period from June, 1936, to June, 1938:

Chairman, H. J. Ball
First Vice-Chairman, G. E. Hopkins
Second Vice-Chairman, R. H. Brown
Secretary, W. H. Whitcomb

This report has been submitted to letter ballot of the committee, which consists of 171 members; 74 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

H. J. BALL,
Chairman.

W. H. WHITCOMB,
Secretary.

APPENDIX

PROPOSED REVISIONS IN STANDARDS FOR TEXTILE MATERIALS

In this appendix are given the proposed revisions in certain specifications and methods of test referred to in the body of the report. In connection with each title is given the reference to the publication in which each standard appears in its present form.

Proposed Revisions of Tentative Standards

Revision of Tentative Definitions and Terms Relating to Textile Materials (A.S.T.M. Designation: D 123 – 35 T):[1]

Reinforced Asbestos Roving.—Change this definition, which appears under "Asbestos Roving," to read as follows by the addition of the italicized words and the omission of those in brackets:

> Reinforced Asbestos Roving.—Reinforced asbestos roving is composed of a core of [cotton] yarn *consisting of vegetable or animal fiber*, covered with a mixture of chrysotile asbestos and [vegetable] *organic* fiber.

Revision of Tentative Methods of Testing and Tolerances for Silk and Cotton Tapes (A.S.T.M. Designation: D 259 – 31 T):[2]

Title.—Change to read as follows by the addition of the italicized word and the omission of the words in brackets:

> Tentative Methods of Testing and Tolerances for [Silk and Cotton] *Woven* Tapes.

Section 3.—Change this section from its present form: namely,

> 3. The thickness of the tape shall not vary from that specified by more than the following amounts:

Thicknesss, in.	Permissible Variations
Up to and including 0.007	±0.0008 in.
Over 0.007 and including 0.011	±0.001 in.
Over 0.011 and including 0.020	±0.0015 in.

to read as follows:

> 3. (*a*) The average thickness of the tape shall not vary from that specified by more than the following amounts:

Nominal Thickness	Permissible Variations, in.
0.011 in. and under	±0.001
Over 0.011 in. up to and including 0.020 in	±0.0015

> (*b*) Individual thickness measurements shall not vary from the nominal thickness specified by more than the following amounts:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1273 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 1345.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 990 (1931); also 1935 Book of A.S.T.M. Tentative Standards, p. 1298.

NOMINAL THICKNESS	PERMISSIBLE VARIATIONS, IN.
0.011 in. and under	±0.0015
Over 0.011 in. up to and including 0.020 in	±0.002

Section 7.—Change this section from its present form: namely,

7. The thickness of the tape shall be determined by a micrometer having measuring faces not less than $\frac{7}{16}$ in. nor more than $\frac{1}{2}$ in. in diameter. Readings shall be made while the micrometer faces hold the tape with just sufficient pressure to permit movement of the tape without distorting the threads.

to read as follows:

7. The thickness of the tape shall be determined in accordance with Method B of the Tentative Methods of Test for Thickness of Solid Electrical Insulation (A.S.T.M. Designation: D 374 – 34 T) of the American Society for Testing Materials.[1]

Section 16.—Add the following sentence at the end of this section on the tensile strength test:

Test results, where specimens break in the jaws of the testing machine, shall be discarded.

New Sections.—Add the tests for sizing content and acidity, appended hereto,[2] to these methods as new Sections 19 to 21, renumbering the remaining sections accordingly:

Revision of Tentative Methods of Testing Pile Floor Covering (A.S.T.M. Designation: D 418 – 35 T):[3]

Section 2.—Change Paragraphs (*c*) and (*d*) of this section to read as follows by the addition of the italicized words and the omission of those in brackets:

(*c*) Standard Condition.—Standard condition of pile fabric is that reached by the fabric in equilibrium with an atmosphere having a relative humidity of 65 per cent [± 2 per cent at 70 to 80 F. (21 to 27 C.)] *at 70 F. (21 C.). A tolerance of ± 2 per cent is permitted in relative humidity and plus 10 F. (6 C.) in temperature.*

(*d*) Moisture Equilibrium.—It shall be considered that moisture equilibrium is reached when, *after free exposure to the standard atmosphere in motion*, two successive weighings not less than 30 min. apart show not more than 1.0 per cent change in weight. *Equilibrium shall be approached from the dry side (not oven dry).*

Section 9.—Change this section from its present form: namely,

9. A section of fabric shall be singed so as to remove the pile yarn without damaging the back construction. The thickness of the remaining back construction in four places shall be determined using the same pressure as in Section 8. The average of four tests shall be the back thickness.

to read as follows:

9. The pile yarn shall be removed from a section of the fabric by clipping. A 5-in. diameter metal ring shall be seated on the clipped portion, a flame directed on the area within the ring, and the pile destroyed with alternate charring and brushing without damage to the back construction. The thickness of the remaining back

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, p. 1069 (1934); also 1935 Book of A.S.T.M. Tentative Standards, p. 1087.

[2] The tests for sizing content and acidity have been incorporated in the revised methods, see p. 1149.—ED.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1229 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 1301.

construction shall be determined by measuring to the nearest 0.001 in. the distance between the two plane surfaces of the back construction under a pressure of 0.750 lb. ± 0.001 lb. per sq. in. distributed over a circular area 1.00 in. ± 0.01 in. in diameter. The pressure shall be applied slowly to avoid impact and the fabric shall be protected from vibration during test. The average of five readings taken at different places within the exposed back construction shall be the back thickness of the sample.

Revision of Tentative Specifications for Textile Testing Machines (A.S.T.M. Designation: D 76 – 35 T):[1]

Section 6.—Change this section from its present form: namely,

6. The jaws or clamps for testing an individual strand of material shall be of the flat grip type, or of the cylindrical or drum type. Those of the latter type shall be so designed that the strand shall pass around not less than 180 deg. of the circumference of the cylinder or drum before being clamped or fixed in the holding device. The length of the specimen shall be considered from center to center of the cylinders or drums. The minimum diameter of the cylinder or drum shall be ½ in.

to read as follows:

6. Jaws or clamps for testing an individual strand of material may be of the flat grip, capstan, drum, or other type, and shall be deemed to be satisfactory provided that not more than 25 per cent of the specimens break at a point within ½ in. of the point of contact with the jaw or clamp.

NOTE.—When a specimen breaks within ½ in. of the point of contact with the jaw or clamp, it is recommended that the results of this test be discarded.

Thickness Gage.—Add as a new Section 7 the following specification requirements covering a gage for measuring thickness:

7. *Thickness Gage.*—(*a*) The gage used for measuring thickness of textile materials shall meet the requirement set forth in Paragraph (*b*), unless otherwise specified.

(*b*) The gage shall be of the dead-weight type equipped with a dial graduated to read directly to 0.001 in. The presser foot shall be circular with a diameter of 0.375 in. ± 0.001 in. The presser foot and moving parts connected therewith shall be weighted so as to apply a total load of 6 oz. ± 0.1 oz. (equivalent to a pressure of 3.4 lb. per sq. in.) to the specimen. The presser foot and anvil surfaces shall be plane to within 0.0001 in. and parallel to each other to within 0.0001 in.

Proposed Revision of Standard

Revision of Standard Specifications for 0.007-in. Cotton Tape for Electrical Purposes (A.S.T.M. Designation: D 335 – 34):[2]

Section 11.—Delete this section on Marking, which reads as follows:

11. Packages shall be plainly and indelibly marked with the size of tape and number of rolls contained therein, the manufacturer's name, and the grade or trade mark.

Section 12.—Delete this section on Shipping, which reads as follows:

12. (*a*) Packages of tape shall be shipped in suitable cases to prevent damage in transit and handling.

(*b*) Cases shall be plainly and indelibly marked with the purchaser's order number, the size of tape, and the number of gross yards contained therein.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1200 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 1266.

[2] 1934 Supplement to Book of A.S.T.M. Standards, p. 202.

REPORT OF COMMITTEE D-17
ON
NAVAL STORES

Two subcommittees of Committee D-17 have been quite active during the year, namely, Subcommittee I on Viscosity of Rosin and Subcommittee IV on Acid and Saponification Number and Unsaponifiable Matter. The work of Subcommittee I has been primarily devoted to bringing about a correlation of the ring-and-ball method of determining softening point of rosin with the work of the Society's Committee E-1 on Methods of Testing concerned with general testing of consistency and plasticity of various materials, more especially of asphalts, tars and pitches. The outcome of this study will, it appears, be the adoption by the Society of a uniform method of test for softening point (so-called melting point) which will be standard for all materials which soften gradually, such as rosin and pitch. The reports of the two subcommittees are given below:

Subcommittee I on Viscosity of Rosin (C. E. Kinney, chairman):

This subcommittee has functioned actively during the past year in assisting the Special Committee, appointed by the Technical Committee on Plasticity, Consistency, etc., of Committee E-1, in its efforts to prepare a modification of the softening point test, ring-and-ball method, which would be acceptable not only to other interested committees, but also to Committee D-17 in lieu of the proposed method of test for viscosity of rosin (ring-and-ball method) developed by Subcommittee I and referred to letter ballot in Committee D-17 in 1933.[1]

Action has been taken by letter ballot in Subcommittee I on the approval of the method prepared by the Special Committee. On the basis of this vote, it is recommended that the ring-and-ball method for softening point[2] as developed by the Special Committee be accepted as a revision of the proposed method of test for the viscosity of rosin (ring-and-ball method).

Subcommittee IV on Acid and Saponification Numbers and Unsaponifiable Matter (R. C. Newton, chairman):

The work on acid and saponification number has brought to the fore the fact that the acid and saponification number of rosin are both subject to and require, for their determination, very meticulous following of a rather empirical method of analysis. The work of the subcommittee during the past year consisted of an examination of cooperative samples of WG and M rosin by methods whose details were more closely written than the methods used by the subcommittee in 1934. The chairman drew up the methods and sent them to the subcommittee members together with carefully prepared samples of WG and M rosin. The subcommittee, at the outset, hoped that by strict adherence to closely written methods they would be able to eliminate the variations and discrepancies which arose in their earlier efforts.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 441 (1933).

[2] The proposed Tentative Method of Test for Softening Point by Ring-and-Ball Apparatus was presented by Committee E-1 on Methods of Testing to the Society through Committee E-10 on Standards and accepted as tentative on August 26, 1936. The method appears on p. 1186.—Ed.

Acid Number and Saponification Number.—The results submitted by the collaborators on cooperative samples, while showing better agreement than had been obtained in the past, still exhibited unsatisfactory divergences. No recommendations regarding methods for acid number and saponification number can therefore be made at this time.

The subcommittee quite generally ascribed the discrepancies to hydrolysis of rosin soap during titration. Mr. Sheely, of Armour and Co.'s laboratory, has made several suggestions for minimizing hydrolysis, which suggestions have met with general approval of the subcommittee members. The subcommittee proposes to rewrite the methods incorporating Mr. Sheely's suggestions modified somewhat as to detail by more recent suggestions from Mr. W. A. Kirklin. The rewritten methods are to be submitted to the members with new rosin samples for further cooperative work.

Unsaponifiable Matter.—The results submitted on the cooperative samples for this determination have been very discouraging, figures diverging as much as 3.7 per cent on the same sample run by different laboratories. No suggestions have yet been developed by the subcommittee for improving this method.

It has been shown by an analyst in Mr. Veitch's laboratory that the nature of the solvent used in making up the saponification solution has quite a marked influence on the saponification number of rosin, which follows similar results obtained by other workers on certain of the fixed oils.

The election of officers resulted in the re-election of the present incumbents for the ensuing term of two years.

This report has been submitted to letter ballot of the committee which consists of twenty members; 18 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

F. P. VEITCH,
Chairman.

C. F. SPEH,
Secretary.

REPORT OF COMMITTEE D-19
ON
WATER FOR INDUSTRIAL USES

Continued progress has been made by the various technical subcommittees of Committee D-19 on their respective programs. Concrete evidence of this progress will be the issuance, as information only, later in the year of methods for the determination of sulfate, hydroxide, total carbon dioxide, and total orthophosphate ions. These methods were based upon research work completed by Subcommittee VIII on Standardization of Water Analysis Methods of the Joint Research Committee on Boiler Feed Water Studies.

The report on methods of sampling which was included as an Appendix to the 1935 report of Committee D-19 has been partially developed in detailed form. An outline of the revised report will be found in the report of Subcommittee III on Methods of Sampling.

Active work is under way in the preparation of methods of analysis of the chloride, calcium, and magnesium ions, and a definite program of work covering other ions in water has been developed by Subcommittee IV on Methods of Analysis.

Action is held in abeyance in the formation of a subcommittee for developing methods of testing for zeolites. Continued progress has been made by a subcommittee of the American Water Works Association and tentative procedures have been published in the Association's *Journal* for September, 1935.

Committee D-19 is sponsoring jointly with the Joint Research Committee on Boiler Feed Water Studies a session on water at the annual meeting of the Society. Papers have been contributed through both organizations.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Policy and Procedure (F. N. Speller, chairman).—During the current year this committee approved the work of the technical subcommittees now in progress. No recommendations have been submitted with respect to new developments.

Subcommittee II, Editorial (Everett P. Partridge, chairman).—The subcommittee completed the editing of referee and control methods for the determination of sulfate, hydroxide, total carbon dioxide, and total orthophosphate ions in water. These methods are based upon the research of Subcommittee VIII of the Joint Research Committee on Boiler Feed Water Studies, and had been referred by Subcommittee IV of Committee D-19 to Subcommittee II for editing. The methods will be issued during the year as information only.[1]

Subcommittee III on Methods of Sampling (R. E. Hall, chairman).—During the year the material published as an Appendix to the 1935 report was broken down in detail, and has been circulated among members of the committee. An outline of the material being worked on follows:

I. Introduction.
II. Scope of report.
III. General principles governing sampling.
III–A. Types of constituents in water.
III–B. Relation of analytical methods to sampling.
III–C. Tests to be made and quantity of sample required.
III–D. Frequency and duration of sampling.
III–E. Point of sampling and sampling technique.
III–F. Time interval between collection and analysis of samples.
III–G. Containers for samples.
III–H. Preservation of samples.
III–I. Labeling and transportation of samples.
III–J. General references on sampling.
IV. Sampling water in the liquid state.
IV–A. Sampling liquid water at atmospheric pressure.
IV–B. Sampling liquid water at super-atmospheric pressure.
IV–C. Sampling liquid water at sub-atmospheric pressure.
V. Sampling water in the vapor state.
VI. Sampling water in the solid state.

Work will be continued during this year in completing the projected program.

Subcommittee IV on Methods of Analysis (J. R. McDermet, chairman).—This subcommittee has received preliminary drafts on proposed methods for the determination of chloride, calcium, and magnesium ions in water. Subcommittee members are active in commenting upon the distributed material. The material will be rewritten within the subcommittee during the year. In addition the program includes the initial preparation of material for the determination of silica, sodium, ferrous and ferric, and aluminum ions. Work will also be undertaken in connection with the material for the measurement of pH value. Action will also be taken on the determination of dissolved oxygen after the progress report of Subcommittee VIII of the Joint Research Committee on Boiler Feed Water Studies is made available at the annual meeting of the Society in June.

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[1] Issued as a separate reprint, October, 1936.

The following officers were elected for the ensuing term of two years:

Chairman, Max Hecht
Vice-Chairman, F. N. Speller
Temporary Secretary, R. E. Hall

This report has been submitted to letter ballot of the committee, which consists of 37 members; 35 members returned their ballots all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

MAX HECHT,
Chairman.

R. E. HALL,
Temporary Secretary.

REPORT OF THE JOINT RESEARCH COMMITTEE

ON

BOILER FEEDWATER STUDIES

On behalf of the Joint Research Committee on Boiler Feedwater Studies, the following report of activities during the past year is presented to the American Society for Testing Materials, one of the six national society sponsors of the committee.

Two major subcommittee activities have been continued with notable success during the past year.

Subcommittee VI on the Effect of Solution Composition on The Cracking of Boiler Metal, under the able guidance of Mr. J. H. Walker of the Detroit Edison Co. has continued the studies which have now been under way for the past three years at the U. S. Bureau of Mines Non-Metallic Station of New Brunswick, N. J. The developments in this study have been reported and published from time to time and are at present common knowledge of industry to which this subject matter is of interest. Two papers presenting some phases of this work are being presented at this meeting.[1] One of these discusses the application of the solubility data, obtained during the early part of the investigation, to the problem of boiler water treatment when the inhibition of caustic embrittlement is sought. The other presents some of the details relating to that phase of the study which has led to the recognition of silica as a factor in the development of embrittlement.

The importance of this silica feature of the study to the complete understanding of the mechanism of the occurrence of embrittlement has been recognized by this committee, Professor Straub and his associates who so ably pioneered the study of the embrittlement phenomenon, and by industry at large.

The continuation of the work of the committee at New Brunswick is being assured by further substantial contributions from industrial groups who sponsored the original work financially. Substantial financial support has been pledged by the Association of American Railroads and the American Boiler Manufacturers Association and Allied Industries. Cooperating in the recommendations of the Utilities Coordinated Research, Inc., the public utility interests have responded generously to the call for further financial support.

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[1] W. C. Schroeder, A. A. Berk and Everett P. Partridge, "Effect of Solution Composition on the Failure of Boiler Steel Under Static Stress at 250 C."; and "The Use of Solubility Data to Control the Deposition of Sodium Sulfate or Its Complex Salts in Boiler Waters," *Proceedings*, Am. Soc. Testing Mats., Vol. 36, Part II, pp. 721 and 755, respectively (1936).

Interchange of data is being maintained with Professor Straub of the University of Illinois where further investigation into this phenomenon is being carried on.

At present it is anticipated that a material advance in the fundamental knowledge of embrittlement will have been made by July, 1938. Earnest efforts will be made to complete the study by that time.

The work of Subcommittee VIII on the examination of methods of water analysis which may be considered as suitable for recommendation as standard, under the chairmanship of A. H. White, has continued the study of methods for the determination of dissolved oxygen.[1] The work of this subcommittee during the past year has yielded two extremely significant results: (1) the development of a well known reaction capable of electrometric measurement for the determination of oxygen in pure water; and (2) the recommendation of a procedure by which oxygen in contaminated water or water containing ions or elements that interfere with the reactions normal to the Winkler procedure may be measured with reasonable accuracy.

A few more questions in connection with these determinations require consideration before the termination of the work now in progress. It is anticipated that the active investigation of water analysis methods on the basis of the present fellowship agreements with the University of Michigan will be terminated October 1 of this year.

Active cooperation is being maintained between the Joint Research Committee and the Society through this subcommittee and A.S.T.M. Committee D-19 on Water for Industrial Uses. Interchange of data and cooperative efforts in the matter of water analysis methods are maintained with the Joint Editorial Committee responsible for the publication of the American Public Health Association "Standard Methods of Water Analysis."

Subcommittee IX on patent literature referring to boiler water treatment, under the direction of Mr. Sheppard T. Powell, is at present engaged in the collection and arrangement of current patent information which will be available to industry late this year.

Active work is now in progress under the direction of A. P. Black, chairman of Subcommittee I on Coagulation and Sedimentation. A report by this subcommittee will be made available later this year.

Subcommittee V on Corrosion, under the temporary chairmanship of F. N. Speller is now in the process of organizing a program of study. Details of this will be available to the sponsor societies during the next few months.

Arrangements have been made to distribute the reports of the several subcommittees of the Joint Research Committee to all persons and organizations contributing to the funds supporting the investigation projects of the

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[1] Alfred H. White, Claude H. Leland and Dale W. Button, "Determination of Dissolved Oxygen in Boiler Feed Water," *Proceedings*, Am. Soc. Testing Mats., Vol. 36, Part II, p. 697 (1936).

Joint Research Committee, as well as to the six sponsor societies for further distribution to interested members.

Steps are also being taken to arrange for the presentation of papers sponsored by the Joint Research Committee as well as subcommittee reports at annual or regional meetings of other sponsor societies. It is felt that in this way the committee can bring to all interested persons and societies the results of its studies in a more direct and useful manner.

Respectfully submitted on behalf of the Joint Research Committee,

C. H. FELLOWS,
Chairman.

R. C. BARDWELL,
Vice-Chairman.

J. B. ROMER,
Secretary.

REPORT OF COMMITTEE E-1

ON

METHODS OF TESTING

Committee E-1 on Methods of Testing held a meeting at Detroit, Mich., on June 27, 1935, subsequent to the presentation of its 1935 report to the Society. A meeting of the Advisory Committee was held on May 9, 1936, at which a number of recommendations, recorded later in this report, affecting the standards and tentative standards for which Committee E-1 is responsible were approved for reference to letter ballot of the committee for submission to the Society at the annual meeting. The technical committees have been active during the year as indicated in the summaries of their work given later in this report.

On the recommendation of the Advisory Committee, consideration will be given during the year to a review of the personnels of the technical committees and sections of Committee E-1 so that the various standing committees of the Society will be adequately represented on those subcommittees whose work is of direct interest.

A canvass by Committee E-1 of the standing committees with reference to their interest in problems dealing with effects of humidity and temperature conditions on the properties of materials indicated that a number of the committees have been considering the conditioning of materials and the establishment of standard atmospheric test conditions. A conference on this subject will be held during this annual meeting in order to provide an opportunity for an exchange of views and for a general discussion of the problems involved, with the thought in mind that Committee E-1 may be of assistance in correlating the present considerations and in furthering future work on the subject.

The Executive Committee of the Society appointed three representatives-at-large to serve on the Advisory Committee, namely, P. G. McVetty, Westinghouse Electric and Manufacturing Co., and the reappointment of W. H. Fulweiler, Consulting Chemist, and H. F. Moore, University of Illinois, each for three-year terms, expiring in 1938.

Committee D-3 on Gaseous Fuels, organized a year ago, has indicated an interest in the work of Committee E-1 and has appointed Mr. C. D. Ulmer, Koppers Construction Co., as its representative on the main committee and on Technical Committees IV on Density, IX on Interpretation and Presentation of Data, and XI on Designation and Interpretation of Numerical Requirements. Dr. A. W. Gauger, Pennsylvania State College, will represent Committee D-3 on Technical Committee V on Determination of Water.

Subsequent to the 1935 annual meeting, Committee E-1 presented to the Society through Committee E-10 on Standards revisions of two tentative standards and one standard, as follows:

Tentative Methods of Verification of Testing Machines (E 4 – 34 T),
Tentative Definitions of Terms Relating to Methods of Testing (E 6 – 32 T), and
Standard Specifications for Round-Hole Screens for Testing Purposes (E 17 – 33) in the form of new Tentative Specifications E 17 – 35 T.

The new specifications and the revisions were accepted[1] by Committee E-10 at a meeting held on August 22, 1935, and the specifications and revised tentative standards appear in their latest form in the 1935 *Proceedings*.[2]

RECOMMENDATIONS AFFECTING STANDARDS

In this report, recommendations affecting standards and tentative standards are noted in brief form below, together with the results of the letter ballot. These recommendations are explained in the reports of the subcommittees directly responsible for them.

I. Proposed Revision of Standard.—The committee recommends for immediate adoption as standard revisions in the Standard Methods of Tension Testing of Metallic Materials (E 8 – 33). The committee accordingly asks for the necessary nine-tenths vote at the annual meeting, in order that these revisions may be referred to letter ballot of the Society for immediate adoption.

II. Adoption of Tentative Standards as Standard.—The committee recommends that the following four tentative standards, with revisions in three as indicated, be approved for reference to letter ballot of the Society for adoption as standard:

Tentative Methods of Verification of Testing Machines (E 4 – 35 T), revised as proposed by the Section on Calibration of Testing Machines and Apparatus,
Tentative Methods of Rockwell Hardness Testing of Metallic Materials (E 18 – 33 T), revised as proposed by the Section on Indentation Hardness Testing,
Tentative Definitions of Terms Relating to Methods of Testing (E 6 – 35 T), revised as proposed by the Section on Elastic Strength of Materials, and
Tentative Specifications for Round-Hole Screens for Testing Purposes (E 17 – 35 T), without revision, to replace the present Standard Specifications E 17 – 33, as proposed by the Section on Coarse Screens.

The recommendations appearing in this report have been submitted to letter ballot of the committee, which consists of 52 members; 35 members returned their ballots, the results being as follows:

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[1] In submitting these recommendations to Committee E-10 on Standards, Committee E-1 reported the following results of the letter ballot vote of a total of 48 ballots returned from a committee membership of 55: Methods E 4 – 34 T, affirmative 41, negative 0, ballots marked "not voting" 7; Definitions E 6 – 32 T, affirmative 38, negative 0, ballots marked "not voting" 10; Specifications E 17 – 35 T, affirmative 28, negative 0, ballots marked "not voting" 20.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, pp. 1303, 1315, 1289 (1935); also 1935 Book of A.S.T.M. Tentative Standards, pp. 1427, 1440, 1364.

Items	Affirmative	Negative	Ballots Marked "Not Voting"
I. PROPOSED REVISION OF STANDARD			
Methods of Tension Testing of Metallic Materials (E 8 – 33), immediate adoption	22	0	13
II. ADOPTION OF TENTATIVE STANDARDS AS STANDARD			
Methods of Verification of Testing Machines (E 4 – 35 T), as revised	27	0	8
Methods of Rockwell Hardness Testing of Metallic Materials (E 18 – 33 T), as revised	23	0	12
Definitions of Terms Relating to Methods of Testing (E 6 – 35 T), as revised	28	1	6
Specifications for Round-Hole Screens for Testing Purposes (E 17 – 35 T)	19	0	16

ACTIVITIES OF TECHNICAL COMMITTEES

Technical Committee I on Mechanical Testing (H. F. Moore, chairman):

During the past year this technical committee, through the work of its sections, has revised and recommended for adoption as standard three tentative methods and also the immediate adoption of changes in one standard method as listed above and referred to further in the following summaries of activities of the sections:

Section on Tension Testing (R. L. Templin, chairman).—This section held a meeting at Pittsburgh in March, 1936, at which consideration was given to desirable changes in the Standard Methods of Tension Testing of Metallic Materials (E 8 – 33).[1] Proposed changes in methods of testing specimens obtained from tubular goods, such as pipe and tubes, were discussed. The meeting was well attended, and the section has been successful in establishing close contacts with other standing committees of the Society.

In order to bring the Standard Methods E 8 into agreement with certain changes made last year by the Section on Elastic Strength of Materials, together with further modifications being proposed this year in the definition of yield strength and with a proposal to substitute "offset" in place of "set" in designating one of the yield strength methods, the committee proposes the following changes which are accordingly recommended for immediate adoption:

Section 25.—Make the same change in the last paragraph of the note to the definition for Elastic Limit as is recommended below in the Tentative Definitions of Terms Relating to Methods of Testing (E 6 – 35 T) by the Section on Elastic Strength of Materials.

Section 26.—In the note under the definition of Yield Strength add the following sentence at the end of Paragraph 1 (*b*):

> For the higher strength steels, a gage length of less than 8 in. is recommended.

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[1] 1933 Book of A.S.T.M. Standards, Part I, p. 949.

In connection with the Set Method, Paragraph 2 (*a*), add as a footnote the following tabulation of values of permissible set:

Yield Strength (or its equivalent) is specified as follows in the standards and tentative standards of the American Society for Testing Materials:

STANDARDS OR TENTATIVE STANDARDS FOR:	LIMITING VALUE OF "OFFSET," PER CENT
Alloy-Steel Pipe	0.2
Aluminum-Alloy Bars, Rods, Shapes, Sheet	
Magnesium-Base Alloy Forgings, Castings, Sheet	
The Alloy: Copper, 80 per cent; Tin, 10 per cent; Lead, 10 per cent	0.5 (elongation under load; approximately equivalent to "offset" of 0.35 per cent)
Copper-Silicon Alloy Plates, Sheets, and Bars	
Malleable Iron Castings	
Sand Castings of Alloy: Copper, 88 per cent; Tin, 8 per cent; Zinc, 4 per cent.	
Aluminum Bronze Castings	
Bronze Bearing Metals and Steam or Valve Sand Castings	
Composition Brass or Ounce Metal Sand Castings	
Naval Brass Rods for Structural Purposes	

Substitute the word "offset" for the word "set" in Paragraphs 2 (*a*) and (*b*) as is recommended below in the Tentative Definitions E 6 – 35 T by the Section on Elastic Strength of Materials.

Add a statement at the end of Paragraph 2 (*a*), Set Method, to read as follows:

> For any given stress the deviation (offset) from Hooke's law is only approximately equal to the set after the removal of that stress, and the approximation becomes less and less exact as the permissible deviation diminishes. This method is devised for determining a stress corresponding to a well marked plastic deformation, or set, and it is not feasible to specify a very small value for the permissible "offset," *Om.*

In Paragraph 2 (*b*), Approximate Method Without Stress-Strain Diagram, change the second sentence to read as follows by the addition of the italicized words and figures and the omission of the words in brackets:

> The total strain can be obtained satisfactorily by use of an extensometer [or in some cases by use of dividers particularly if the surface of the specimen is prepared so that the line made by the dividers is a fine line and if it is observed through a reading glass] *reading to 0.0001 in. per inch of gage length.*

Section on Compression Testing (M. F. Sayre, chairman).—This section is continuing its study on the revision of the Tentative Methods of Compression Testing of Metallic Materials (E 9 – 33 T). The question of speed of testing is very important in compression tests, and the section is keeping in close touch with the Section on Effect of Speed of Testing and the experimental work on the speed of testing concrete in compression.

Section on Bend Tests for Ductility (A. B. Kinzel, chairman).—This section has had the serious misfortune to have all the data of its work for the last two years lost in an explosion which took place in one of the cooperating laboratories. These data are being slowly reassembled from the original sources. The section has been in contact with the Section on Testing Thin Sheet Metals and the two sections are working together on ductility tests of thin sheet metals.

Section on Indentation Hardness Testing (J. R. Townsend, chairman).—This section held a meeting at Pittsburgh in March, 1936, at which action was taken to recommend the adoption as standard of the Tentative Methods of Rockwell Hardness Testing of Metallic Materials (E 18 – 33 T)[1] with the following revision:

Section 1.—Change the table of standard scales appearing in this section from its present form to read as follows:

SCALE SYMBOL	PENETRATOR	MAJOR LOAD, KG.	DIAL FIGURES
	GROUP ONE		
B	$\frac{1}{16}$-in. ball	100	Red
C	"Brale"	150	Black
	GROUP TWO		
A	"Brale"	60	Black
D	"Brale"	100	Black
E	$\frac{1}{8}$-in. ball	100	Red
F	$\frac{1}{16}$-in. ball	60	Red
G	$\frac{1}{16}$-in. ball	150	Red
H	$\frac{1}{8}$-in. ball	60	Red
K	$\frac{1}{8}$-in. ball	150	Red
	GROUP THREE		
L	$\frac{1}{4}$-in. ball	60	Red
M	$\frac{1}{4}$-in. ball	100	Red
P	$\frac{1}{4}$-in. ball	150	Red
R	$\frac{1}{2}$-in. ball	60	Red
S	$\frac{1}{2}$-in. ball	100	Red
V	$\frac{1}{2}$-in. ball	150	Red

NOTE.—The above scales are offered as standard scales and designations and are intended for the convenience of the user. These scales overlap at their extremities. Therefore, it is considered good practice to use a scale that gives readings in the mid range. There are other possible scales which might be used for special purposes but the above designations are recommended.

The desirability of standardizing the "superficial" Rockwell hardness test was considered by the section at its meeting and methods of Rockwell hardness testing on circular bars, rods and tubes were discussed. It was recognized that the question of details of hardness tests on rods and tubes should be left with the standing committees whose work deals with these materials.

Section on Testing Thin Sheet Metals (C. H. Marshall, chairman).—This section has been endeavoring to assemble available data respecting the various tests used in the testing of thin sheet metals. During the past several years the section sponsored two round-table discussions, one in 1933 on the "Use of the Tension Test for Judging the Suitability of Sheet Materials for Various Purposes,"[2] and the other in 1934 on "Hardness Testing of Sheet Metals." In order to make possible the mutual exchange of information on the ductility or drawing properties of sheet metals, including cupping tests, bend tests, etc., a subject which is becoming of increasing importance in the testing of sheet metals, a third round-table discussion was arranged by this section in cooperation with the Section on Bend Tests for Ductility. This discussion meeting which was devoted to a consideration of "Ductility Testing of Sheet Metals" was held on June 26, 1935, in Detroit, Mich., during the 1935 annual meeting of the Society. The program for the discussion meeting was developed by a special committee, consisting of A. L. Davis, chairman, and C. H. Greenall. These several meetings have provided excellent opportunities for the mutual exchange of ideas and experiences by both sheet manufacturers and users of sheet metals for the purpose of increasing the general fund of knowledge on the testing of sheet materials.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 967 (1933); also 1935 Book of A.S.T.M. Tentative Standards, p. 1377.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, p. 563 (1934).

This section has also obtained, by means of a questionnaire, information on the use, limitations and significance of tests used on thin sheet metals from a number of engineers and technologists in the United States and several correspondents in England who are interested in this subject. This information which will be summarized for further consideration by the committee will be of assistance to the section in furthering its activities.

Section on Flexure Testing (H. F. Clemmer, chairman).—This section held a meeting at Pittsburgh in March, 1936, and is carrying on a study of the effect of the span-depth ratio on flexure strength.

Section on Impact Testing (W. W. Werring, chairman).—This section held a meeting at Detroit, Mich., in June, 1935, at which consideration was given to a joint request from the Committee on Pipe of the Association of American Steel Manufacturers Technical Committees and Subcommittee IX on Steel Tubing and Pipe of A.S.T.M. Committee A-1 on Steel for inclusion in the Tentative Methods of Impact Testing of Metallic Materials (E 23 – 34 T) of special specimens suitable for pipe. Discussion developed the desirability of tension-impact tests for this field and led to agreement on a preliminary joint investigation by this section, Subcommittee IX and the A.A.S.M. committee.

Section on Effect of Speed of Testing (P. G. McVetty, chairman).—This section held a meeting at Pittsburgh in March, 1936. At this meeting there was a lengthy discussion of the problem of speed of testing and the problem of distinguishing between (*1*) actual effect on the properties of the materials of speed of testing and (*2*) effect on test results due to methods of handling testing machines, which appeared to be of great importance.

The section has cooperated in the program of investigative studies on the effect of varying the speed of testing upon the strength and other properties of concrete being carried out at the University of Illinois. This work was made possible by a contribution from the research fund of the Society provided through Committee E-9 on Research. A report on the present series of tests which covers studies of the relation between rate of loading and the compressive strength of concrete and observations of the effect of rate of loading on the stress-strain relation for the concrete in compression is presented in a paper by Paul G. Jones and F. E. Richart entitled "The Effect of Testing Speed on Strength and Elastic Properties of Concrete"[1] being presented at this annual meeting of the Society.

Section on Calibration of Testing Machines and Apparatus (H. F. Moore, chairman).—At the meeting of this section at Pittsburgh in March, 1936, certain slight revisions in the present Tentative Methods of Verification of Testing Machines (E 4 - 35 T)[2] were completed and action was taken to recommend the adoption of these tentative methods as standard with the following revisions:

Section 19.—Add a note at the end of this section to read as follows:

> NOTE.—If the magnitude of deformation of the elastic calibration device is measured with a self-indicating dial micrometer or dial indicator, the elastic calibration device shall be used only at the test loads for which it has itself been calibrated by comparison with a primary standard. It shall be used only when the deformation measuring apparatus is so adjusted that the no-load reading of the device is nearly equal to the no-load reading observed during the calibration of the elastic calibration device.

Section 29.—Change the second sentence of this section to read as follows, by the addition of the italicized words:

> Testing machines shall, however, be verified immediately after making repairs or adjustments of the weighing mechanism *after the testing machine has been moved (this does not apply to portable testing machines)*, and whenever there is reason to doubt the accuracy of the results, without regard to the time interval since the last verification.

The question of calibration of strainometers has been discussed as a suitable activity for this section.

Section on Elastic Strength of Materials (F. B. Seely, chairman).—This section held a meeting at Pittsburgh in March, 1936, at which action was taken to recommend for adoption as standard the definitions of the terms "elastic limit" and "yield strength" appearing in the Tentative Definitions of Terms Relating to Methods of Testing (E 6 - 35 T)[3] with the following minor revisions:

Elastic Limit.—Change the last paragraph of the note to the definition for Elastic Limit from its present form: namely,

> In certain specifications of the Society, the term "Elastic Limit" is used to designate a value obtained by a test method which does not involve the release of stress during a test, but which does involve the determination of a limiting load at which there occurs an appreciable increase in rate of strain with respect to stress. This

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 36, Part II, p. 380 (1936).

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1303 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 1427.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1315 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 1440.

method may determine, for some materials, a satisfactory value of the proportional elastic limit, but the property termed "Yield Strength" determined by the "set method" as described below, is felt to be a more widely satisfactory and significant measure of the desired strength property of the material.

to read as follows:

> For certain grades of steel a special method of determining elastic strength is recognized in the standard specifications of the American Society for Testing Materials. See the Standard Specifications for Quenched-and-Tempered Alloy-Steel Axles, Shafts and Other Forgings for Locomotives and Cars (A.S.T.M. Designation: A 63), for Carbon-Steel and Alloy-Steel Forgings (A.S.T.M. Designation: A 18), and for Quenched-and-Tempered Carbon-Steel Axles, Shafts and Other Forgings for Locomotives and Cars (A.S.T.M. Designation: A 19).

Yield Strength.—In Paragraph 2 (*a*) of the note to the definition of yield strength, change the designation of the method from "Set Method" to read "Offset Method."

Change the second and fourth sentences of the second paragraph under 2 (*a*) to read as follows by the addition of the italicized words and the omission of the word in brackets:

> *The offset* Om will then give the approximate value of the permanent set after the release of the stress OR. Thus to determine the yield strength by the "[set] *offset* method," it is necessary to secure data (autographic or numerical) from which a stress-strain diagram may be drawn.

Change the third and fourth paragraphs under 2 (*a*) to read as follows by the addition of the italicized words and the omission of those in brackets:

> In reporting values of yield strength obtained by this method, the specified value of "[set] *offset*" used should be stated in parentheses after the term yield strength. Thus:
>
> Yield strength ([set] *offset* = 0.1 per cent) = 52,000 lb. per sq. in. indicates that at a stress of 52,000 lb. per sq. in. the approximate permanent set of the material reached the value of 0.1 per cent of the original gage length.

In footnote 1 change the word "set" to read "offset" wherever it appears.

As an editorial correction change the second sentence of the fifth paragraph under 2 (*a*) from its present form: namely,

> It will be observed that the elastic limit and proportional limit are special values of the yield strength in which the specified limiting set is not measurable with the instruments used and hence is considered to be zero.

to read as follows:

> The elastic limit and the proportional limit may be regarded as special values of the yield strength. They are the highest stresses for which the "set" and the "offset," respectively, are not measurable with the instruments used and hence are considered to be zero.

Change the last sentence of the sixth paragraph under 2 (*a*) to read as follows by the addition of the italicized word and the omission of the word in brackets:

> This method is devised for determining a stress corresponding to a well marked plastic deformation, or set, and it is not feasible to specify a very small value for the permissible "[set] *offset*," Om.

Paragraph 2 (b).—Change the last sentence of this paragraph to read as follows by the addition of the italicized word and the omission of the word in brackets:

> But it is recommended that this approximate method be used only after agreement between producer and consumer, with the understanding that check tests be made for obtaining stress-strain diagrams for use with the [set] *offset* method to settle any misunderstandings.

Technical Committee II on Consistency, Plasticity, Etc. (E. C. Bingham, chairman):

The technical committee held a meeting at Pittsburgh in March, 1936, at which consideration was given to a number of problems before this committee in correlating the work of the standing committees of the Society dealing with consistency, plasticity and viscosity of materials. In view of the increasing interest in its work the committee has extended invitations for membership on the committee to other organizations and qualified individuals.

The American Society of Mechanical Engineers has appointed Dr. A. Nadai as its representative and the American Ceramic Society has designated Mr. F. H. Norton. Dr. E. O. Kraemer of the E. I. duPont de Nemours Co. and Mr. R. L. Peck of the Bell Telephone Laboratories have accepted membership on the committee. The addition to the committee personnel of two foreign representatives, namely, Dr. Guy Barr, National Physical Laboratory, England, and Dr. C. J. Van Nieuwenburg, Technische Hoogeschool, Delft, Holland, will keep the committee informed respecting developments in England and on the Continent.

The committee is giving consideration to the fundamental conceptions of the definition of viscosity and the units of absolute viscosity, the poise centipoise and centistoke, and to methods of determining viscosity in absolute units. It is believed that the publication of these fundamental rheological conceptions will be of considerable assistance in educating many of our standing committees to the advantages to be derived from the use of absolute units. The committee is desirous of obtaining the opinion of the national societies on this subject.

In order to provide further opportunity for the receipt of constructive comment and suggestions respecting the Tentative Definitions of Terms Consistency and Plasticity (E 24 – 34 T) it is recommended that they be continued as tentative for another year, without change.

The Special Committee on Softening Point Test (H. M. Hancock, chairman), after studies extending over approximately two years, has completed the development of a Method of Test for Softening Point by

Ring-and-Ball Method, appended hereto,[1] which is intended as a revision of and to replace the present Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (D 36 – 26), originally prepared by Committee D-4 on Road and Paving Materials. As mentioned in the 1934 and 1935 reports[2] this work was undertaken since the existing standard method, while used by a number of the standing committees, was not entirely satisfactory for determining the softening point of certain materials. The scope of the revised method has been enlarged and in addition to testing bituminous materials is now applicable to rosins and most resins, both natural and synthetic. Details of the test apparatus and procedure have been improved, including the use of a tapered ring and an increase in the range of the high softening point thermometer. It is expected that at the June meeting of Committee E-1 this method will be approved by the committee for reference to letter ballot, and if favorably acted upon by letter ballot subsequent to the meeting, will then be submitted to the Society through Committee E-10 on Standards for acceptance for publication as tentative.[3]

The technical committee wishes to record its appreciation to the members of this special committee, consisting of H. M. Hancock, chairman, C. E. Kinney, E. O. Rhodes and T. Smith Taylor, for the service they have rendered in the development of this method.

In connection with the submission of this revised method, the committee is presenting the following data showing the relation between softening point and absolute viscosity at different temperatures for several materials, in order to present a true conception of the consistency:

MATERIAL	SOFTENING POINT, RING-AND-BALL METHOD, DEG. CENT.	ABSOLUTE VISCOSITY AT 35 C., POISES
Coal Tar Products	27.1 38.2	1.25×10^3 2.00×10^4
Asphalts	47.8 55.6	2.50×10^5 1.18×10^6
Coal Tar Pitches	65.2 72.4	1.51×10^7 4.34×10^8
Rosin	73.0 74.0	7.33×10^9 8.32×10^8

Technical Committee III on Particle Size and Shape (L. T. Work, chairman):

This technical committee has for its general duties the supervision of methods of particle size measurement. To that end, it desires to work in coöperation with such other committees of the Society as have problems dealing with particle size of materials. Where a method is designed or prepared specifically for an industry or a particular product, it is naturally expected that the appropriate committees in that field will prepare or make specific proposals. In such event, Technical Committee III acts as a supervisory and correlative committee. It must be stressed in this connection that correlation of methods is essential in order that a minimum number of standards on a particular subject may be adopted and that, in so far as possible, methods specifically applicable in one field may be broadened to have general usefulness.

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[1] See p. 1186.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 34 and 35, Part I, pp. 554 and 493 (1934 and 1935), respectively.

[3] See Editorial Note, p. 526.—ED.

The technical committee is cooperating with the Sectional Committee on Sieves for Testing Purposes (A.S.A. Project Z23) and recommendations which the sectional committee may make respecting the specifications for sieve standards will be considered by the respective sections of this technical committee.

Section on Sub-Sieve Sizes (D. L. Gamble, chairman).—This committee specifically studies methods of general applicability and is particularly interested at the present time in the problem of sub-sieve size methods, in which field many new methods of measurement are being developed. During the year the chairman of this section, Mr. G. S. Haslam, has found the nature of his work such that he did not feel that he could continue to direct this committee effectively and he has resigned. It is understood that Mr. Haslam will advise fully with this committee at all times. Dr. D. L. Gamble of the New Jersey Zinc Co. has been appointed chairman to succeed Mr. Haslam and there has accordingly been no delay in the continuity of the work.

Before recommending the adoption of the Tentative Method of Analysis for the Particle Size Distribution of Sub-Sieve Size Particulate Substances (E 20 – 33 T)[1] the section believes that further study should be given to improving the method so as to obtain better reproducibility of results by different operators.

The section is giving further consideration to the proposed Method of Measurement of Average Particle Diameter of Sub-Sieve Particulate Substances by Dark Field Methods which was published as information with the report of Committee E-1 last year.[2]

Section on Coarse Sieves (F. H. Jackson, chairman).—This section is recommending the adoption as standard of the Tentative Specifications for Round-Hole Screens for Testing Purposes (E 17 – 35 T)[3] presented last year as a tentative revision of the Standard Specifications for Round-Hole Screens for Testing Purposes (E 17 – 33),[4] which standard will accordingly be discontinued.

Technical Committee IV on Methods for Density (H. W. Bearce, chairman):

The chairman is reviewing the various methods of test for density and specific gravity prescribed in the standards of the Society for the purpose of undertaking a correlation of the present test procedures. This technical committee has received from Committee C-8 on Refractories a request that consideration be given to the establishment by the National Bureau of Standards of a reference sample of silica brick for specific gravity determinations.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 989 (1933); also 1935 Book of A.S.T.M. Tentative Standards, p. 1399.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 505 (1935).

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1289 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 1364.

[4] 1933 Book of A.S.T.M. Standards, Part II, p. 1242.

Technical Committee VI on Volatility (T. Smith Taylor, chairman):

The chairman has reviewed the previous work of this committee and has in preparation a detailed summary of the present methods for volatility, distillation, loss on heating and extraction as a basis for developing a program of study in correlating the existing tests. The committee will hold a meeting during this annual meeting at which it is hoped to further this work.

Technical Committee VII on Chemical Composition (G. E. F. Lundell, chairman):

No meetings of this technical committee have been held during the past year. The committee believes that in the future it will be desirable to continue its activities as a liason group and as a body qualified to act in a supervisory capacity in case the Society decides to compile and publish collectively the methods of chemical analyses, covering the procedures for both metals and non-metallic materials, which are at present covered by existing standards and appear in separate parts of the Book of A.S.T.M. Standards.

An important step during the year has been the consolidation in the recently organized Committee E-3 on Chemical Analysis of Metals of the work previously carried on by the various subcommittees of the standing committees on ferrous and non-ferrous metals which were previously responsible for the formulation of analytical procedures for metals.

The Subcommittee on Analysis of Ferrous Metals of Committee E-3 has been active and has completed the preparation of extensively revised and improved methods of chemical analysis of steel, cast iron, open-hearth iron and wrought iron which include procedures for the determination of carbon, manganese, phosphorus, sulfur, silicon, copper, nickel, chromium, vanadium, molybdenum, titanium and tungsten. These methods represent revisions of and, when adopted, are intended to supersede the present standard methods of chemical analysis of plain carbon steel, alloy steel, and pig and cast iron.

Technical Committee VII has been asked to cooperate with Committee C-4 on Clay Pipe in revising the chemical tests that are prescribed in the Standard Specifications for Clay Sewer Pipe (C 13 – 35). This work is under way and may be completed during the coming year.

Technical Committee VIII on Thickness Measurements (W. E. Emley, chairman):

During the summer of 1935, suggested modifications of the requirements dealing with the measurement of thickness in 34 A.S.T.M. standards or tentative standards were prepared by this technical committee. These proposed changes took the form of actual rewording of the paragraphs affected, in order that the standing committees concerned can, if they see fit, adopt the new wording verbatim. The suggested revisions, with the reasons therefor, were forwarded, through the representatives on this committee, to the chairmen of the respective standing committees. The present status is as follows: Committee D-8 on Bituminous Waterproofing and Roofing Materials referred the matter for consideration to one of its subcommittees at the March, 1936, meeting. Committee D-9 on Electrical Insulating Materials adopted certain of the revisions at a meeting on November 7, 1935, but the entire matter has not yet been completed. Committee D-11 on Rubber Products discussed the revisions at various subcommittee meetings in March, 1936, but no definite action has as yet been taken. Committee D-13 on Textile Materials adopted the revision in so far as the Standard General Methods of Testing Woven Textile Fabrics (D 39 – 34) are concerned. Action in regard to individual standards was temporarily deferred. It will be seen from the above that satisfactory progress in this work is being made slowly.

Technical Committee IX on Interpretation and Presentation of Data (Anson Hayes, chairman):

This technical committee submitted to the Society in 1933 a Manual on Presentation of Data.[1] This Manual was widely circulated, which made necessary a reprinting of it in March, 1934.

The technical committee has decided that it would add to this Manual by means of supplements, additional sections or material as they became available or seemed to be required, until in the end the Manual might be considered one having to do with interpretation and presentation of data. The first two supplements, were completed last year and cover the following: Supplement A, "Presentation of ±Limits of Uncertainty of an Observed Average," and Supplement B, "'Control Chart' Method of Analysis and Presentation of Data." Both supplements were published in the 1935 *Proceedings*[2] and have also been issued in a separate reprint pamphlet. The usefulness of the work of the technical committee has been increased considerably by these supplements to the Manual. The work of the committee will continue to be developed further along these lines.

The technical committee has advised various committees and subcommittees of the Society in connection with certain problems dealing with data and statistical methods.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 453 (1933).

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, pp. 1411 and 1418 (1935).

Technical Committee XI on Designation and Interpretation of Numerical Requirements (J. A. Gann, chairman):

This technical committee has in preparation recommended practices for the designation of numerical requirements in standards which are intended to be of assistance to the various standing committees of the Society in the use of uniform terms and conventions in expressing the numerical requirements in specifications and methods of testing, and to facilitate the correct interpretation of such requirements. In preparing these recommendations the committee is endeavoring to outline practices which should aid in clarifying the intended meaning of limiting and tolerance values, with which test values are compared in acceptance and rejection of materials. It is proposed to include also certain non-numerical terms closely related to numerical expressions. The recommendations are intended for application to the standards of the Society as they bear on the acceptance and rejection of the material, as distinguished from research or other scientific work.

A draft of the recommended practice was considered at a meeting of the technical committee at Pittsburgh in March, 1936, and subsequent to the meeting a Survey Committee, consisting of R. W. Crum, H. F. Dodge, J. A. Gann, G. E. Hopkins, H. Walter Leavitt, G. E. F. Lundell, H. F. Moore, and R. T. Webster, has given considerable thought and attention to content, typographical form and arrangement of the various sections of the recommended practice. The proposed recommended practices were completed during the annual meeting and are published as information as an Appendix to this report.

The election of officers resulted in the re-election of the present incumbents for the ensuing term of two years.

This report has been submitted to letter ballot of the committee which consists of 52 members; 35 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

W. H. FULWEILER,
Chairman.

P. J. SMITH,
Ex-officio Secretary.

EDITORIAL NOTE

Subsequent to the annual meeting Committee E-1 on Methods of Testing presented to the Society on August 26, 1936, through Committee E-10 on Standards a proposed Tentative Method of Test for Softening Point by Ring-and-Ball Apparatus. This recommendation was accepted and the method appears on p. 1186.

APPENDIX

PROPOSED RECOMMENDED PRACTICES
FOR
DESIGNATION OF NUMERICAL REQUIREMENTS IN STANDARDS[1]

This is a **proposed draft** and is published as information only. Comments are solicited and should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Scope

1. (*a*) These recommended practices are intended to assist the various standing committees in the use of uniform terms and conventions in expressing the numerical requirements in specifications and methods of testing, and to facilitate the correct interpretation of such requirements. Their aim is to outline practices which should aid in clarifying the intended meaning of limiting and tolerance values, with which test values are compared in acceptance and rejection of material. Certain non-numerical terms closely related to numerical expressions are also included.

(*b*) It is understood that these recommendations apply to the Society's standards as they bear on the acceptance and rejection of material.

(*c*) Definite interpretations are assigned to the following:

(*1*) The phrase "to the nearest........", when applied to a specified limit (see Section 3 (*b*)).

(*2*) The underlining of figures in a specified limit, for example, "$\underline{1.500}$" (see Section 3 (*c*)).

(*3*) The symbol " ±," when applied to a specified value of maximum permissible deviation (see Section 4 (*a*)).

(*4*) The term "average" (see Section 5 (*a*)).

Reference to These Practices in Standards

2. The inclusion of the following paragraph, or a suitable equivalent, immediately after the section on "Scope" in any standard shall constitute due notification that numerical requirements in that standard are subject to the interpretations set forth in these recommended practices:

Interpretation of Numerical Requirements.—The numerical requirements of this standard are subject to the interpretations set forth in the Proposed Recommended Practices for the Designation of Numerical Requirements in Standards of the American Society for Testing Materials. Particular attention is called to the use of—(insert one of the following): (*1*) the phrase "to the nearest ...."; (*2*) underlining; (*3*) underlining and use of the phrase "to the nearest ...."—in expressing specified limits.

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[1] Under the standardization procedure of the Society, these recommended practices are under the jurisdiction of the A.S.T.M. Committee E-1 on Methods of Testing.

Expression of Numerical Requirements

3. The unqualified statement of a numerical limit, such as "2.50 in. max.", cannot, in view of different established practices and customs, be regarded as carrying a definite operational meaning

as to the number of places of figures to be read on the scale of measurement, or

as to the number of places of figures to be retained in an observed or calculated value for purposes of acceptance and rejection.

Measurement.—In some fields, specified values of 2.5 in. max., 2.50 in. max., 2.500 in. max., are taken to imply that a length determination should be made to the nearest 0.1 in., 0.01 in., 0.001 in., respectively. In other fields, no such significance is attached to this difference of expression.

Acceptance and Rejection.—In some fields, specified values of 2.5 in. max., 2.50 in. max., 2.500 in. max., are taken to imply that for purposes of acceptance and rejection, observed values or calculated values should be rounded off to the nearest 0.1 in., 0.01 in., 0.001 in., respectively. In other fields, these three specified values are taken to imply the same absolute limit of two and one-half inches and that no deviation, however small, in excess of this value is allowed.

Clear meaning on these points can be assured only by specifying the following operations:

(*1*) *How measurement values are to be obtained, and*

(*2*) *How the observed values or calculated values are to be handled when they are compared to specified values in determining acceptability of material.*

In specifying operation (*1*), the following items should be included:

The test or analytical method to be followed,
The type of measuring device to be used,
The units of measurement to be used, and
The number of places of figures to be read on the scale of measurement.

A recommended method of specifying operation (*2*) is given in the following paragraphs of this section.

(*a*) Numerical requirements should be so expressed that the number of places of figures to be considered significant for purposes of acceptance and rejection, are clearly indicated. If a limited number of places of figures are to be considered significant for this purpose, this intent may be expressed:

(*1*) by the phrase "to the nearest ....", as follows:

to the nearest 10 lb.
to the nearest 0.2 mg.
to the nearest 0.0001 in.

(*2*) by underlining the significant places, as follows:

Sulfur.................................	$\underline{0.20}$ per cent, max.
Width.................................	$\underline{27.50}$ in., max.
Tensile strength........................	$\underline{62}$,000 lb. per sq. in., min.

(*3*) by a direct statement.

The use of the phrase "to the nearest............", or of underlining, is recommended.

(*b*) *Meaning of Phrase "to the nearest......".*—**The phrase, "to the nearest......", when applied to specified limits, shall be interpreted to have the meaning that an observed value or a calculated value is, for purposes of acceptance and rejection, to be rounded off in the following manner:**

SPECIFIED LIMIT	OBSERVED VALUE OR CALCULATED VALUE	ROUNDED VALUE TO BE USED FOR ACCEPTANCE PURPOSES
Diameter (to the nearest 0.001 in.): 1.500 in., max	1.4992	1.499
	1.5004	1.500
	1.5005[a]	1.501
	1.5006	1.501
Tensile strength (to the nearest 2000 lb. per sq. in.): 60,000 lb. per sq. in., min	58 990	58 000
	59 000[a]	60 000
	59 010	60 000
	61 000	62 000
Antimony (to the nearest 0.01 per cent): 0.90 per cent, min	0.894	0.89
	0.895[a]	0.90
	0.896	0.90
	0.906	0.91

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[a] An observed value or a calculated value falling exactly half-way between two adjacent rounded values is, for purposes of acceptance and rejection, taken to have the next higher rounded value.

(*c*) *Meaning of the "Underlining" Symbol.*—**Underlining, when applied to specified limits, shall be interpreted to have the meaning that an observed value or a calculated value is, for purposes of acceptance and rejection, to be rounded off to the nearest unit in the last right-hand place of figures underlined.**

NOTE.—Thus, underlining is the simple equivalent of the phrase "to the nearest 10, 1, 0.1, .01, etc."

The rounding-off method, illustrated in the following examples, is as follows: In rejecting places of figures to the right of those underlined in the specified limit, increase by 1 the last figure retained when the first left-hand figure rejected is 5 or greater, otherwise leave it unchanged.[1]

SPECIFIED LIMIT	OBSERVED VALUE OR CALCULATED VALUE	ROUNDED VALUE TO BE USED FOR ACCEPTANCE PURPOSES
Diameter, 1.500 in., max	1.4992	1.499
	1.5004	1.500
	1.5005	1.501
	1.5006	1.501
Tensile strength, 30,000 lb. per sq. in., min	29 490	29 000
	29 500	30 000
	29 510	30 000
	30 500	31 000
Antimony,[a] 0.90 per cent., min	0.894	0.89
	0.895	0.90
	0.896	0.90
	0.906	0.91

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[a] The above expression of the requirement for antimony shall be interpreted to mean that a numerical value of percentage of antimony determined from analysis, shall be rounded off to the nearest 0.01 per cent for purposes of acceptance and rejection. A value of 0.895 per cent, obtained from the results of laboratory analysis, would be rounded off to give the value 0.90 per cent. This conforms with the specified limit.

[1] See "Supplement A—Presenting Plus and Minus Limits of Uncertainty of an Observed Average," to 1933 A.S.T.M. Manual on Presentation of Data, *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1141 (1935); also available as separate pamphlet.

(*d*) *Digits to be Selected.*—If the phrase, "to the nearest ....", is used, values 1, 2, 5 (multiplied or divided by 10, 100, etc.) are preferred to values 3, 4, 6, 7, 8, 9, etc. and are preferred to fractional values $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{6}$, $\frac{1}{8}$, $\frac{1}{16}$, etc., or their decimal equivalent.

Example:

Use values of....................................	0.01,	0.02,	0.05
	0.1,	0.2,	0.5
	1,	2,	5
	10,	20,	50, etc.
in preference to values of..............................	0.03,	0.04,	0.06
	0.3,	0.4,	0.6
	3,	4,	6
	30,	40,	60, etc.
and in preference to values of............................	$\frac{1}{3}$ (0.333)		
	$\frac{1}{4}$ (0.25)		
	$\frac{1}{6}$ (0.167)		
	$\frac{1}{8}$ (0.125)		
	$\frac{1}{16}$ (0.0625), etc.		

NOTE.—If the digit 1 is selected, underlining is a simple equivalent of the phrase, "to the nearest............"

(*e*) *Decimals.*—Decimals should be used in preference to fractions in expressing numerical requirements. Prevailing custom, as in some length measurements, may call for use of values $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{16}$, $\frac{1}{32}$, $\frac{1}{64}$, etc., but it is recommended that consideration be given in individual cases to preferred use of 0.2, 0.1, 0.05, 0.02, 0.01, 0.001, etc., particularly for smaller values.

(*f*) *Comments.*—The use of the phrase "to the nearest............", or of underlining, in designating specified limits, in effect specifies that the operation of "rounding off" observed or calculated values shall be considered applicable in determining whether those values are conforming or non-conforming with the specified limit.

It is recommended that the "rounding off" method (indicated by the use of the phrase "to the nearest............", or by underlining) be employed as widely as possible in designating limits for dimensions. In view of the fact that well established gage-tolerance and other practices in some fields do not employ the principle of "rounding off" here discussed, the use of the phrase "to the nearest............," and of underlining, may not be considered universally applicable to all dimensional requirements. Where other procedures are to be used, it is recommended that the standard contain a direct statement as to the practice intended by the committee originating the specification. Clear expression on this point should aid in preventing misunderstandings and disagreements in instances where observed values are marginally close to specified values.

It is recommended that the phrase "to the nearest............", or underlining, be used generally in designating percentage chemical composition requirements, and that the number of decimal places used in expressing limiting values be the same as the number of decimal places to be considered significant for purposes of acceptance and rejection.

In the interests of simplicity of expression, a general statement, used as a caption or a footnote, should be used in preference to repetitions of the phrase "to the nearest ....", or to repeated underlining, in instances where the "rounding off" method is to be specified for a large number of similar requirements. Suggestions as to how this may be accomplished are given in the following examples:

(*1*) If the "rounding-off" method is to apply to all specified limits in the standard and all expressed figures are to be considered significant, this may be indicated by adding a sentence to the notification paragraph given in Section 2, as follows:

> *Interpretation of Numerical Requirements.*—The numerical requirements of this standard are subject to the interpretations set forth in the Proposed Recommended Practices for the Designation of Numerical Requirements in Standards of the American Society for Testing Materials. Particular attention is called to the use of—(insert one of the following): (*1*) the phrase "to the nearest ...."; (*2*) underlining; (*3*) underlining and use of the phrase "to the nearest ...."—in expressing specified limits. The following applies to all specified limits in this standard: For purposes of acceptance and rejection, an observed value or a calculated value should be rounded off "to the nearest unit" in the last right-hand place of figures used in expressing the limiting value.

(*2*) If the "rounding off" method is to apply to all specified limits in a table, this may be indicated by a caption or by a footnote in the manner indicated in the following examples:

Example 1.—Same significant places for all items in a table (illustrating the use of a caption):

	CHEMICAL COMPOSITION, PER CENT (to the nearest 0.1 per cent)
Copper	4.5 ± 0.5
Iron	1.0 max.
Silicon	2.5 ± 0.5
Other constituents (magnesium + zinc + manganese)	0.5 max.
Aluminum	remainder

Example 2.—Same significant places for all items in a table, with one or two exceptions (illustrating the use of a caption and a footnote):

	CHEMICAL COMPOSITION, PER CENT (to the nearest 0.1 per cent)
Aluminum	6.0 ± 0.7
Zinc	3.0 ± 0.5
Manganese	0.15 min.[a]
Copper	0.05 max.[a]
Silicon	0.5 max.
Other constituents (cadmium + tin + nickel) (nickel 0.03 max.[a])	0.3 max.
Magnesium	remainder

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[a] To the nearest 0.01 per cent.

Example 3.—Significant places not the same for all items in a table (illustrating the use of a footnote):

	CHEMICAL COMPOSITION, PER CENT	
	MIN.	MAX.
Nickel	57	....
Chromium	14	18
Manganese	....	3
Silicon	....	0.40
Carbon	....	0.25
Sulfur	....	0.03
Iron	remainder	

NOTE.—The following applies to all numerical requirements in this table: For purposes of acceptance and rejection, an observed value or a calculated value obtained from an analysis should be rounded off "to the nearest unit" in the last right-hand place of figures used in expressing the limiting value.

Limits

4. Specifications should indicate limits to the range of permissible variations of acceptable material. These may be expressed by the use of maximum and minimum values, or maximum permissible plus and minus deviations. If there is a preferred value within the range of permissible variations, it should be indicated.

(*a*) *Double Limits With Preference.*—If there is a preferred value, it should be indicated together with maximum and minimum values, or maximum permissible plus and minus deviations.

Example:

Antimony	0.98 per cent, preferred 0.90 per cent, min. 1.10 per cent, max.

or

Antimony	0.98 per cent, preferred − 0.08 per cent + 0.12 per cent

If the preferred value lies half-way between limits, the maximum deviations permissible may be expressed by the use of the " ± " sign. **An expression using the " ± " sign shall be interpreted to indicate a preferred value,** and is thus to be considered as having a different meaning from the statement of merely a maximum and a minimum value (see Section 4 (*b*)).

Example:

Antimony	1.00 per cent ± 0.10 per cent

(*b*) *Double Limits Without Preference.*—If there is no preference for a specific value, maximum and minimum values alone should be indicated.

Example:

Weight	23.40 lb., min. 23.50 lb., max.
Length (to the nearest 0.5 in.)	17.0 in., min. 18.0 in., max.

(*c*) *Single Limit With Preference.*—If the requirements demand a limit in only one direction and there is a preferred value, the preferred value should be indicated together with the maximum or minimum value.

Example:

Width	27.00 in., preferred 27.50 in., max.
Weight of coating (to the nearest 0.2 mg. per sq. in.)	10.0 mg. per sq. in., preferred 2.0 mg. per sq. in., min.

(*d*) *Single Limit Without Preference.*—If the requirements demand a limit in only one direction and there is no preference for a specific value, a maximum or minimum value alone should be indicated.

Example:

Sulfur	0.2 per cent, max.
Weight of coating (to the nearest 0.2 mg. per sq. in.)	2.0 mg. per sq. in., min.

(*e*) *Percentage Maximum Permissible Deviations.*—If the maximum permissible plus or minus deviation is a direct function of the preferred value, it may be expressed as a percentage, particularly if a wide range of preferred values is expressed or accepted by custom.

Example:

The twist, in turns per inch to the nearest turn, shall be as specified, ± 7 per cent.

The resistance in ohms per foot at 20 C. shall be as specified, ± 10 per cent; to the nearest 0.001 ohm for gages Nos. 14 to 21, to the nearest 0.01 ohm for gages Nos. 22 to 31, and to the nearest 0.1 ohm for gages Nos. 32 to 40. On the basis of this specification, the table of minimum and maximum values to be used for purposes of acceptance and rejection would be as follows:

	Resistance, ohm per foot at 20 C.		
Wire Gage	Min.	Specified	Max.
No. 14	0.145	0.161	0.177
No. 15	0.183	0.203	0.223
.....	.....	.....	.....
.....	.....	.....	.....
.....	.....	.....	.....
No. 21	0.732	0.813	0.894
No. 22	0.93	1.03	1.13
.....	.....	.....	.....
.....	.....	.....	.....
.....	.....	.....	.....
No. 31	7.50	8.33	9.16
No. 32	9.3	10.3	11.3
.....	.....	.....	.....
.....	.....	.....	.....
.....	.....	.....	.....
No. 39	48.7	54.1	59.5
No. 40	56.0	73.3	80.6

NOTE.—The following applies to all specified limits in this table: For purposes of acceptance and rejection, an observed value or a calculated value obtained by test should be rounded off "to the nearest unit" in the last right-hand place of figures used in expressing the limiting value.

Averages

5. (*a*) **Where the term "average" is used without modifying adjectives, it shall be interpreted to indicate the arithmetic mean.** If some other average is intended, such as the weighted arithmetic mean, the geometric mean, etc., the standard should so state.

(*b*) Standards should indicate clearly whether specified limits are to be applied to each single reading, to the average of all readings, to the average of certain subgroups of readings, etc.

(*c*) If the places of figures to be considered significant in an average differ from those expressed in the specified limit for a single specimen, a statement should be made to this effect.

Non-Numerical Terms

6. The following expressions are not numerical in character but have a definite relationship to numerical requirements in standards.

(*a*) *Remainder, Balance, or Difference.*—The analytical method should, in general, include the determination of all the essential ingredients and all of the impurities for which numerical requirements are specified. The term "remainder" (rather than "balance" or "difference") should be used when it is not necessary to make a direct determination of the remaining constituent or constituents involved.

Example:

	CHEMICAL COMPOSITION, PER CENT (to the nearest 0.1 per cent)
Copper	4.5 ± 0.5
Iron	1.0 max.
Silicon	2.5 ± 0.5
Other constituents (magnesium + zinc + manganese)	0.5 max.
Aluminum	remainder

(*b*) *Trace, None, Nil.*—The use of indefinite terms, such as "trace," "none," "nil" should be avoided unless defined as "none by such and such a test."

(*c*) *Total Impurities.*—The use of indefinite expressions, such as "total impurities," "total other impurities," etc., should be avoided unless the specification likewise lists the elements that should be considered under such expressions.

Test Method

7. The standard should indicate clearly the test or analytical method to be followed for each of the specified numerical requirements. This may be done as follows:

(*1*) By reference to A.S.T.M. Standard,
(*2*) By reference to an approved method, or
(*3*) By describing the method in detail.

Tolerances for Controlled Constants of Test

8. Tolerances for controlled constants of testing apparatus and equipment should be designated.

Example:

Thickness test............ "............with a load of 0.100 ± $\underline{0.001}$ lb. per sq. in. distributed over a circular area of 3.00 ± $\underline{0.01}$ in. in diameter."

Tensile strength test.......... "...........with a jaw speed of 12.00 ± $\underline{0.50}$ in. per minute."

In the above examples the underlining designates places of figures to be considered significant for purposes of acceptance and rejection *of conditions of test.*

Tolerances for Condition of Sample

9. The physical condition of the sample at the time of test should be specified in all details which influence the characteristics being tested.

Example:

Molded Insulating Materials, Physical Tests.—All specimens shall be conditioned before testing by drying in an oven at 50 C. ± $\underline{5}$ C. for 48 hr., followed by cooling to room temperature in a desiccator.

Woven Textile Fabrics, Physical Tests.—Standard condition of woven fabrics shall be that reached by the fabric when in moisture equilibrium with a standard atmosphere having a relative humidity of 65 per cent at 70 F. (21 C.). A deviation of ±2.0 per cent is permitted in relative humidity and +10 F. (+6 C.) in temperature.

Sampling and Acceptance Requirements

10. (*a*) If it is the intent of the specification to provide a definite basis for acceptance and rejection with respect to the numerical requirements, the sampling procedure should be outlined in detail, including:

(*1*) Method of selecting samples,
(*2*) Number of tests or analyses,
(*3*) Acceptance requirements—including (*a*) conditions to be met by results of tests if lot is to be considered acceptable and (*b*) conditions for and methods of resampling and retesting.

(*b*) If there are restrictions as to the number of specimens, tests, or readings to be permitted in obtaining an average for purposes of acceptance and rejection, the standard should so state.

Test Readings

11. Where it is important in any operation of a test or an analysis, the specification should indicate how many places of figures the tester or analyst should read on the scale of measurement.

Example:

Measure to the nearest 0.001 in.
Read to the nearest 10 lb.
Weigh to the nearest 0.01 g.
Read to the limit of sensitivity of the............

If the direct reading of a test is taken in the same units of measurement as designated in the specified limit, and if the phrase "to the nearest............" (or underlining) is used in designating the specified limit, this method of expression will indicate to how many places of figures it is *necessary* to read purely for purposes of acceptance and rejection. The practice of reading and recording *additional* places of figures is recommended; among other things, this practice makes available information that may be useful in studies or investigations as to variability of material or of testing methods.

Example:

Specified Limit: Weight......5.0 g., min.

For purposes of acceptance and rejection, it would be *necessary* to read the scales of the balance only to the nearest 0.1 g. If, however, it were subsequently desirable to review past data to study variability, and if the range of variation were only say one or two tenths of a gram, the amount of information available would be meager if values had been recorded only to the nearest tenth of a gram, but would be plentiful if values had been recorded to the nearest hundredth of a gram.

Calculations

12. (*a*) The basis of all percentages should be given.

(*b*) It is recommended that all calculations, such as determinations of tensile strength in pounds per square inch, corrections for temperatures, etc., should carry at least two more places of figures than are to be considered significant for purposes of acceptance and rejection.

Example.—The specified tensile strength of a material is 50,000 lb. per sq. in., min., that is, two places of figures are to be considered significant for purposes of acceptance and rejection. This recommendation calls for carrying out calculations to four places of figures.

If maximum load readings for two test specimens are 5340 and 5090 lb., and if the calculated cross-sectional areas are 0.1024 and 0.1029 sq. in., respectively, the calculated values of the tensile strength would be as follows:

$$\frac{5340}{0.1024} = 52{,}150 \text{ lb. per sq. in.}$$

$$\frac{5090}{0.1029} = 49{,}470 \text{ lb. per sq. in.}$$

Note that if the recommendation in Paragraph (*b*) had not been followed and if only *one* more place of figures (than are to be considered significant for acceptance and rejection) had been used, the second calculated value would have been 5090/0.103 = 49,600 lb. per sq. in. This value would then have been rounded off to 50,000 and would have been considered *acceptable*, whereas it should have been considered *rejectable*. Using "two more places" in calculations, in accordance with the practice here recommended, prevents this type of calculation error from affecting the final value used for purposes of acceptance and rejection.

(*c*) Digits that are not to be considered in acceptance values should be rounded off (see Section 3 (*b*) and (*c*)) after all calculations, including averaging, are completed:

Example.—Calculated figures of Section 12 (*b*) would be rounded off to give final values of 52,000 and 49,000 lb. per sq. in., respectively, for purposes of acceptance and rejection.

REPORT OF COMMITTEE E-2

ON

SPECTROGRAPHIC ANALYSIS

Committee E-2 on Spectrographic Analysis held one meeting during the year in connection with the annual meeting of the Society in Detroit, Mich., June 27, 1935. As a result of actions taken at that meeting the following three methods were submitted during the year to Committee E-10 on Standards, accepted as tentative on October 7, 1935, and published in the 1935 *Proceedings:*[1]

Tentative Methods of Test for:

Quantitative Spectrochemical Analysis of High Grade Pig Lead for Copper, Bismuth, Silver and Nickel (E 25 – 35 T).

Quantitative Spectrochemical Analysis of Zinc for Lead, Iron and Cadmium (E 26 – 35 T).

Zinc Alloy Die Castings for Minor Constituents and Impurities (E 27 – 35 T).

Quantitative Spectrochemical Analysis of Zinc Alloy Die Castings for Minor Constituents and Impurities (E 27 – 35 T).

No action has been taken by the committee on the formulation of additional standards nor on the adoption as standard of the present tentative methods. It is felt that the committee should await reports on experience with the present tentative standards before taking further action.

Six new members have been elected to membership during the year, and four corporation members have designated second representatives. There has been one change of representative by a corporation member and one resignation, increasing the personnel to 46 individuals. The chairman appointed A. W. Kenney to serve as the representative of Committee E-2 on the Inter-Society Color Council.

Subcommittee III on Quantitative Methods and Applications (M. L. Fuller, chairman) has been studying through a sub-subcommittee appointed at the Detroit meeting the question of sampling methods to insure that analyses made by the tentative methods shall be truly representative of the materials involved.

Subcommittee V on Standards and Pure Materials (T. A. Wright, chairman) has devoted considerable time to the question of making available pure metals of accurately known composition to serve as standards for calibration in quantitative work. It has also been considering various questions connected with the standardization of materials for arc and spark electrodes.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, pp. 1352 to 1368 (1935); also 1935 Book of A.S.T.M. Tentative Standards, pp. 1478 to 1494.

The election of officers for the ensuing term of two years resulted in the selection of H. V. Churchill, chairman; T. A. Wright, vice-chairman; and C. C. Nitchie, secretary.

This report has been submitted to letter ballot of the committee which consists of 41 members; 20 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

H. V. CHURCHILL,
Chairman.

C. C. NITCHIE,
Secretary.

REPORT OF COMMITTEE E-3
ON
CHEMICAL ANALYSIS OF METALS

Committee E-3 on Chemical Analysis of Metals was formally organized at a meeting held during the 1935 annual meeting of the Society. The adopted scope of the committee is as follows:

> *Scope.*—The preparation of standard methods of chemical analysis of metals, including methods of sampling and tolerances in values obtained in chemical analyses of metals.

Prior to the organization of the committee, each of the Society's standing committees in the metals field had its own subcommittee on chemical analysis. Since the methods of chemical analysis of the various metals, both ferrous and non-ferrous, had much in common and are carried out to a large extent by the same technologists, considerable duplication was entailed, both in the personnel of the individual subcommittees and in publication of the standard procedures. This suggested the desirability of having one standing committee responsible for all work on methods of chemical analysis to which the individual standing committees would refer their problems in this field. The organization of Committee E-3 followed after consulting with the various standing committees concerned.

In addition to its jurisdiction over analytical procedures, the committee will also be responsible for methods of sampling metals for chemical analysis. Since the usual methods of chemical analysis are frequently carried out in conjunction with analyses made by spectrographic methods, Committee E-3 plans to cooperate closely with Committee E-2 on Spectrographic Analysis. By-laws governing the activities of the committee, supplementary to the general Society's Regulations, are now being prepared and, on the basis of these by-laws, a more complete subcommittee organization will be developed.

The Subcommittee on Analysis of Ferrous Metals has been active and has completed the preparation of extensively revised and improved proposed Tentative Methods of Chemical Analysis of Steel, Cast Iron, Open-Hearth and Wrought Iron which include procedures for the determination of carbon, manganese, phosphorus, sulfur, silicon, copper, nickel, chromium, vanadium, molybdenum, titanium and tungsten. These methods represent revisions of and, when adopted, are intended to supersede the present Standard Methods of Chemical Analysis of Plain Carbon Steel (A 33 – 24), Standard Methods of Chemical Analysis of Alloy Steels (A 55 – 24), Standard Methods of Sampling Rolled and Forged Steel Products for Check Analysis (A 130 – 30) and Standard Methods of Sampling and Chemical Analysis of Pig and Cast Iron (A 64 – 27). It is expected that at the June meeting of Committee E-3 the proposed methods will be approved by the committee and favorably acted upon by letter ballot and will then be submitted to the Society through Committee E-10 on Standards for acceptance for publication as tentative. The subcommittee is giving consideration at the present time to methods for the determination of aluminum, zirconium, cobalt, columbium, nitrogen, oxides, etc.

In the non-ferrous field, methods for the determination of nickel and silicon have been prepared for inclusion in the Standard Methods of Chemical Analysis of Brass Ingots and Sand Castings (B 45 – 27). It is also planned to revise the procedures for the determination of lead, tin, and iron which are at present covered in the Standard Methods B 45.

The committee also has under consideration the desirability of reverting to the tentative status all of the existing standard methods of analysis under its jurisdiction applicable to ferro-alloys and the non-ferrous metals as it is planning to develop further procedures on these subjects and to consolidate certain of the present methods.

A method for the determination of aluminum in iron-chromium-aluminum alloy (37.5 per cent chromium and 5 per cent or more aluminum) is in process of formulation.

The election of officers resulted in the re-election of the present incumbents for the ensuing term of two years.

This report has been submitted to letter ballot of the committee which consists of 27 members; 23 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

G. E. F. LUNDELL,
Chairman.

H. A. BRIGHT,
Secretary.

EDITORIAL NOTE

Subsequent to the annual meeting Committee E-3 on Chemical Analysis of Metals presented to the Society on August 26, 1936, through Committee E-10 on Standards the following recommendations:

Proposed Tentative Methods of Chemical Analysis of Steel, Cast Iron, Open-Hearth Iron and Wrought Iron to replace four existing standard methods.

The four standards which were accordingly withdrawn are as follows:

Standard Methods of:

Chemical Analysis of Plain Carbon Steel (A 33 – 24)
Chemical Analysis of Alloy Steels (A 55 – 24)
Sampling Rolled and Forged Steel Products for Check Analysis (A 130 – 30)
Sampling and Chemical Analysis of Pig and Cast Iron (A 64 – 27)

Reversion to tentative status of fourteen existing standard methods, as follows:

Standard Methods of:

Sampling Ferro-Alloys (A 103 – 27)
Chemical Analysis of Ferro-Alloys (A 104 – 27)
Chemical Analysis of Ferrotungsten and Ferromolybdenum (A 104 – 34)
Chemical Analysis of Alloys of Lead, Tin, Antimony and Copper (B 18 – 21)
Chemical Analysis of Manganese Bronze (B 27 – 19)
Chemical Analysis of Gun Metal (B 28 – 19)
Battery Assay of Copper (B 34 – 20)
Chemical Analysis of Pig Lead (B 35 – 24)
Chemical Analysis of Slab Zinc (Spelter) (B 38 – 21)
Chemical Analysis of Aluminum and Light Aluminum Alloys (B 40 – 35)
Chemical Analysis of Nickel (B 41 – 23)
Chemical Analysis of Brass Ingots and Sand Castings (B 45 – 27)
Chemical Analysis of Bronze Bearing Metal (B 46 – 27)
Chemical Analysis of Silver Solders (B 81 – 33).

These recommendations were accepted and all of the tentative methods of chemical analyses of the ferrous and non-ferrous metals appear in "A.S.T.M. Methods of Chemical Analyses of Metals, 1936."

REPORT OF COMMITTEE E-4
ON
METALLOGRAPHY

The outstanding activities of Committee E-4 on Metallography during the year have been the work of Subcommittee VI on X-ray Methods under the chairmanship of R. F. Mehl in arranging for the Symposium on Radiography and X-ray Diffraction Methods, and of Subcommittee IV on Photography under the chairmanship of L. V. Foster in revising the Standard Rules Governing the Preparation of Micrographs of Metals and Alloys (E 2 – 30).

Committee E-4 and the Special Subcommittee on Revision of Grain-Size Chart for Classification of Steels held meetings in Pittsburgh, Pa., on March 5, 1936.

RECOMMENDATIONS AFFECTING STANDARDS

I. Proposed Revision of Standard.—The committee recommends for immediate adoption as standard a revision of the Standard Rules Governing the Preparation of Micrographs of Metals and Alloys, Including Recommended Practice for Photography as Applied to Metallography (E 2 – 30) as appended hereto.[1] The committee accordingly asks for the necessary nine-tenths vote in order that this revision may be referred to letter ballot of the Society for immediate adoption. This recommendation has been submitted to letter ballot of the committee which consists of 49 members; 40 members returned their ballots, of whom 39 have voted affirmatively, 0 negatively, and 1 member marked his ballot "not voting."

II. Adoption of Tentative Standard as Standard.—The committee recommends that the Tentative Recommended Practice for Metallographic Testing of Ferrous and Non-Ferrous Metals (E 3 – 35 T) be approved for reference to letter ballot of the Society for adoption, with the minor changes proposed by Subcommittee I as given later in this report. This recommended practice represents a revision of and is intended to replace the Standard Methods of Metallographic Testing of Iron and Steel (E 3 – 24) and the Standard Methods of Metallographic Testing of Non-Ferrous Metals and Alloys (E 5 – 27) which standards are accordingly to be withdrawn. This recommendation has been submitted to letter ballot of the committee which consists of 49 members; 40 members returned their ballots, of whom 38 have voted affirmatively, 0 negatively, and 2 members marked their ballots "not voting."

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[1] See 1936 Book of A.S.T.M. Standards, Part I, p. 763.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Selection and Preparation of Samples (E. H. Dix, Jr., chairman).—Subcommittee I is following new developments in metallographic testing. This subcommittee has recommended that with the minor changes given below the Tentative Recommended Practice for Metallographic Testing of Ferrous and Non-Ferrous Metals (E 3 – 35 T)[1] be approved for reference to letter ballot of the Society for adoption as standard. This recommended practice is intended to replace the present Standard Methods of Metallographic Testing of Iron and Steel (E 3 – 24)[2] and the Standard Methods of Metallographic Testing of Non-Ferrous Metals and Alloys (E 5 – 27),[2] and it is accordingly recommended that with the adoption of the recommended practice these standards be discontinued.

Table I.—Change the first clause under "Remarks" for Reagent No. 6 to read as follows by the addition of the italicized phrase:

> Most useful for mild steel, particularly bessemer *and other high nitrogen* steel.

Table II.—Add the following material as "Reagent No. 8A" after Reagent No. 8:

ETCHING REAGENT	COMPOSITION		REMARKS	USES
No. 8A. Oxalic acid	Oxalic acid...... H_2O............	10 g. 100 ml.	Electrolytic; 3 to 6 v. from dry cell or storage battery. The specimen is anode; platinum or stainless steel is cathode. Time, 15 to 45 sec.	For revealing precipitated carbides and grain boundaries in stainless steel.

Two references to original literature will be included in the bibliography appended to the Recommended Practice.

Subcommittee IV on Photography (L. V. Foster, chairman).—This subcommittee has completed a revision of the Standard Rules Governing the Preparation of Micrographs of Metals and Alloys, Including Recommended Practice for Photography as Applied to Metallography (E 2 – 30)[3] in the form of completely revised rules appended hereto[4] which are recommended for immediate adoption as standard to replace the present standard.

Subcommittee VI on X-ray Methods (R. F. Mehl, chairman).—Subcommittee VI has continued its excellent work started last year and has completed arrangements for the Symposium on Radiography and X-ray Diffraction Methods which will be held at this annual meeting of the Society There will be four sessions of this Symposium at which twelve papers will be presented by outstanding authorities in their special fields.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1319 (1935); also 1935 Book of A.S.T.M. Tentative Standards, p. 1445.

[2] 1933 Book of A.S.T.M. Standards, Part I, pp. 909, 922.

[3] *Ibid.*, p. 900.

[4] See 1936 Book of A.S.T.M. Standards, Part I, p. 763.

Special Subcommittee on Revision of Grain-Size Chart for Classification of Steels (O. E. Harder, chairman).—This special subcommittee held a meeting in Pittsburgh, Pa., on March 5, 1936, and has carried on considerable correspondence. At the meeting in Pittsburgh by a majority vote a proposed revision of the Standard Grain Size Chart for Classification of Steels (E 19 – 33) was approved. This proposed revision was submitted to letter ballot of Committee E-4 as a majority report. At the same time a minority report proposing an addition to the majority report which would provide for determination of grain size in steel without carburization was also submitted to Committee E-4 for letter ballot. The results of the vote indicated that the majority of Committee E-4 favor a revision of the present standard which provides for the determination of grain size by the McQuaid-Ehn carburizing test but also that a majority of the members favor, in addition, the setting forth of some method for determining the grain size without carburization.

The special subcommittee recommends that it be discharged and a new subcommittee appointed to give further consideration to the revision of the Standard E 19 – 33 with a view to working out a revision which will express the wishes of Committee E-4.

The election of officers for the ensuing term of two years resulted in the selection of the following:

Chairman, J. T. Norton
Vice-Chairman, M. A. Grossman
Secretary, J. J. Bowman

This report has been submitted to letter ballot of the committee which consists of 49 members; 38 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

C. H. DAVIS,
Chairman.

O. E. HARDER,
Secretary.

REPORT OF COMMITTEE E-9
ON
RESEARCH

With this report Committee E-9 presents a brief summary of some of the research projects being carried on under the auspices of the Society. A more comprehensive review will be published as usual in the October, 1936, issue of the Society *Bulletin*.

Research Committee Activities:

The Research Committee on Yield Point of Structural Steel has in progress a short series of tests to determine the effect of aging on the yield point of structural steel rods. Experiments were begun last fall with the cooperation of the Carnegie-Illinois Steel Corp. and the Bethlehem Steel Co., Inc , and the data will be completed the latter part of this year. It is expected that a report will be made at the annual meeting in 1937.

The Research Committee on Fatigue of Metals is reporting currently to the Society at this annual meeting.[1] The cooperative arrangement with *Metals and Alloys* in the preparation of monthly abstracts of articles concerning fatigue of metals for publication in that journal has been continued. Cooperative work with Committee E-4 on Metallography on the use of X-ray methods as a means of detecting impending fatigue failure has likewise been continued, the studies having been made at the Metals Research Laboratory of the Carnegie Institute of Technology. There is appended to the committee's report a statement on X-ray diffraction as a means of detecting impending fatigue failure. The report also includes other pertinent notes and comments on fatigue studies.

The Joint Committee on Investigation of the Effect of Phosphorus and Sulfur in Steel is presenting at this annual meeting a final report on effect of sulfur in steel which briefly summarizes its work in this field and the conclusions that have been drawn by the committee.[2] The Joint Committee had hoped that during the year commercial conditions might warrant it in proceeding with the further projected study of effect of phosphorus in steel castings. However, a careful review of the present situation has led to the conclusion that the Joint Committee's work is completed so far as present commercial demands are concerned and that further projects should not be undertaken at this time. The committee has accordingly requested the various societies that have sponsored its work to permit it to disband. Committee E-9 has concurred for A.S.T.M. in this proposal, with the understanding that if at some future time a proposal is made for further studies regarding the effect of phosphorus or sulfur in steel, it could be brought to the attention of A.S.T.M. and the National Bureau of Standards for handling in whatever manner would seem best suited to the circumstances.

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[1] See p. 123.
[2] See p. 88.

The Joint Research Committee of the A.S.M.E. and A.S.T.M. on Effect of Temperature on the Properties of Metals is presenting a progress report to its sponsor societies, which is on the program of the present annual meeting.[1] Substantial progress is reported by the committee in various studies, including long-time (three year) tests at Battelle Memorial Institute and other cooperative short-time and long-time tension tests at high temperatures carried out under the procedures prescribed respectively in the A.S.T.M. Tentative Methods of Test E 21 – 34 T and E 22 – 35 T. The results of cooperative impact tests at low temperatures are also reported this year. A report on the Battelle tests, now in the second year, is summarized in an appendix to the Joint Committee's report. Last December the Joint Committee sponsored a special session at the annual meeting of the American Society of Mechanical Engineers at which four committee reports were presented.

In the past few years the Joint Committee has been concentrating its activities on the study of creep in ferrous metals with the idea of arriving at a better understanding of such phenomena in ferritic and austenitic steels. It is planned to continue this work, but the committee points out in its report that it is not unmindful of the fact that creep is but one of a number of factors that need to be studied in relation to application of metals for high-temperature and low-temperature service, and it plans to sponsor work relating to other properties. Additional funds for the completion of present researches and inauguration of new projects are urgently required and the Joint Committee is now engaged in procuring such funds from industries concerned with the utilization of metals at high and low temperatures. Contributions from thirty-four firms totaling $16,800 are acknowledged in the current report of the committee; it is hoped to raise at least $18,000 in support of the committee's work.

The Joint Committee on Boiler Feedwater Studies, on which the Society has been represented for a number of years and for which it has recently become a co-sponsor with five other societies, is presenting a brief résumé of its activities at this annual meeting,[2] supplemented by three technical papers also on the program, which constitute reports of researches carried out under the direction of the Joint Committee.[1] Provision has been made for coordination of the work of the Society's Committee D-19 on Water for Industrial Uses with that of the Joint Research Committee.

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[1] See p. 127.
[2] See p. 510.

The Joint Committee on Correlation of Research in Mineral Aggregates functioning under the auspices of the Highway Research Board of the National Research Council, is engaged at present in a study of the so-called Los Angeles abrasion test of aggregates.

Research Projects by Standing Committees:

One of the functions of Committee E-9 is to review annually the progress of the Society's research activities. In the October, 1935, *Bulletin* summaries of all new projects and of existing projects on which committees presented additional information and data were published. Project cards for all research activities are maintained by Committee E-9 and are brought up to date annually by reviewing the reports of the standing and research committees. A revised and up-to-date review of the current research projects will appear in the Society *Bulletin* next October. Members of the Society should refer to that review for a comprehensive picture of the nature of, and the progress being made in, those researches.

There will be mentioned here only one of these projects which, however, is probably the biggest one of its kind the Society has ever undertaken, namely, an investigation of resistance to corrosion (at eleven test sites from coast to coast) of galvanized and other types of metallic-coated wire, strand, farm fencing and chain link fencing, including some compositions of stainless steel. This project is under the sponsorship of Committee A-5 on Corrosion of Iron and Steel with the cooperation of manufacturers of wire and fencing, a number of state agricultural colleges, the National Bureau of Standards and many individuals and companies who have long been active in the work of that committee. It is much more comprehensive than was contemplated when Committee A-5 first initiated its studies of corrosion of metallic-coated products some ten years ago and the committee is seeking further contributions to its research funds to meet the increased expenses involved. The investigation is expected to extend over a period of twenty years. Including materials and services to be contributed by both producers and consumers of these products and by the several agricultural colleges, it has been conservatively estimated that this research will cost not less than $100,000.

A general account of this project will appear in the Society *Bulletin*, and Committee A-5 plans a full report on the initiation of the tests with its annual report in 1937.

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[1] See papers by Alfred H. White, Claude H. Leland and Dale W. Button, "Determination of Dissolved Oxygen in Boiler Feed Water"; W. C. Schroeder, A. A. Berk and Everett P. Partridge, "Effect of Solution Composition on the Failure of Boiler Steel Under Static Stress at 250 C."; W. C. Schroeder, A. A. Berk and Everett P. Partridge, "The Use of Solubility Data to Control the Deposition of Sodium Sulfate or Its Complex Salts in Boiler Waters," *Proceedings*, Am. Soc. Testing Mats., Vol. 36, Part II, pp. 697, 721, 755 (1936).

New Activities:

A study on effect of speed of testing on strength and elastic properties of concrete was completed during the year at the laboratories of the University of Illinois under the joint sponsorship of the University and the Society. The desirability of such a study was pointed out in the report of Committee E-9 last year; it was found that the University was in a position to proceed with this study, towards which it was agreed to contribute the sum of $600 from the A.S.T.M. Research Fund. The work was done under the immediate direction of F. E. Richart, Research Professor of Engineering Materials, University of Illinois, who conferred with the following advisory committee appointed by Committee E-9: M. O. Withey, chairman, D. E. Parsons, P. G. McVetty. The Section on Effect of Speed of Testing of Committee E-1 on Methods of Testing has been following this project. The report on the investigation is in the form of a paper on the program of the present annual meeting, entitled "The Effect of Testing Speed on Strength and Elastic Properties of Concrete," by Paul G. Jones and F. E. Richart.[1]

A suggestion that this investigation be continued to study the effect of various variables upon speed-strength and speed-stiffness relations, with particular attention to the phenomena of inelastic short-time and long-time creep of concrete, is under consideration.

Committee E-9 has directed a communication to standing committees of the Society requesting the committees to bring promptly to its attention any research projects for which financial assistance within the means of the Society's Research Fund would be helpful.

Some consideration is being given to corrosion problems involved in the operation of air-conditioning equipment. An informal conference of individuals, companies and various committees of the Society was held on this subject in Pittsburgh last March, which included representatives of appropriate committees of the American Society of Heating and Ventilating Engineers. H. W. Gillett, a member of Committee E-9, presided at the conference. A further survey of the problems here involved will be made by the A.S.H.V.E. and A.S.T.M. through a special joint committee to be appointed for that purpose.

Committee E-9's report last year presented in some detail the nature of certain much-needed fundamental studies of the durability of masonry materials. It has not been possible to make much progress in this direction during the past year. Funds for a year's work have become available to the National Bureau of Standards for studying the durability of various types of masonry construction, brick walls and some lighter types of wall construction; other funds have been obtained for some work on durability of mortars for unit construction. The Bureau is also continuing certain studies of durability of granite. There is still need, however, for a much more comprehensive study of this subject along lines suggested by this committee a year ago.

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[1] *Proceedings,* Am. Soc. Testing Mats., Vol. 36, Part II, p. 380 (1936).

There has recently been a rather notable increase in research on bituminous materials, principally as applied to highway construction problems. These researches are going on in the laboratories of the Bureau of Public Roads, various State Highway Departments and various producers. This has given added significance to plans that have been under consideration both in this committee and in Committee E-6 on Papers and Publications for a symposium on bituminous materials at either a regional or annual meeting of the Society. The committee has asked one of its members, J. S. Miller, Jr., to outline such a symposium in time for consideration by the Committee on Papers and Publications for next year's annual meeting.

Administrative Matters:

J. S. Miller, Jr., was appointed to membership on the committee in June, 1935, succeeding H. F. Moore, whose term expired at that time. This year the term of office of H. W. Gillett expires, and T. S. Fuller has been appointed for the term of five years.

The principal of the A.S.T.M. Research Fund was substantially increased during the year and now totals $10,165.50. During the year, in addition to the $600 contributed to the project on effect of speed of testing on concrete as noted above, contributions of $100 to the Boiler Feedwater Studies Committee and approximately $43 to the Research Committee on Yield Point of Structural Steel were made. The balance of income as of May 31, 1936, is $1460.31.

Respectfully submitted on behalf of the committee,

P. H. BATES,
Chairman.

C. L. WARWICK,
Secretary.

REPORT OF COMMITTEE E-10
ON
STANDARDS

The activities of Committee E-10 on Standards during the past year are set forth under the following heads: Review of A.S.T.M. standardization activities, consideration of new and revised standards and tentative standards, promotion and expansion of standardization activities, and relations with American Standards Association.

As in the previous year, a very considerable number of new tentative standards and revisions of existing standards and tentative standards have been submitted to Committee E-10 during the year for approval. For the most part these were considered at the regular meeting of the committee held in Philadelphia, Pa., on August 22, 1935.

Beginning with the annual meeting of the Society in June, 1934, the personnel of the committee was placed on a rotational basis and in accordance with this plan Mr. R. P. Anderson of the American Petroleum Institute and Mr. H. S. Mattimore of the Pennsylvania State Highway Department were appointed to serve as members of the committee for a three-year term to succeed Mr. T. G. Delbridge and Mr. T. R. Lawson.

REVIEW OF A.S.T.M. STANDARDIZATION ACTIVITIES

A general summary of the new tentative standards submitted at the 1935 annual meeting, of tentative standards adopted as standard and of revisions in standards was included in the July issue of the A.S.T.M. *Bulletin*, together with a review of the standardization work of the various committees with statements concerning new standards in prospect. Much of the information, particularly in respect to standardization projects under development in committees, is furnished by the standing committees subsequent to the annual meeting and takes advantage of the fact that many committees plan their next year's work at committee meetings held during the annual meeting.

At the present writing, it is possible to make only an approximate estimate in terms of new and revised standards of the volume of standardization work accomplished during the year and reported to the Society at this meeting. The reports of standing committees to be presented at the annual meeting include recommendations to the Society substantially as follows:

New tentative standards	48
Revisions of existing tentative standards	38
Tentative revisions of existing standards	7
Tentative standards recommended for adoption as standard	77
Revisions of existing standards recommended for adoption as standard	70
Standards and tentative standards withdrawn	49

There are at present 504 standards and 290 tentative standards of the Society, making a total of 794, and if the above recommendations are approved this total will become 793.

CONSIDERATION OF NEW AND REVISED STANDARDS

Proposed new standards approved by Committee E-10 and published as tentative during the year are as follows:

Tentative Specifications for:

Carbon-Steel Plates for Boilers and Other Pressure Vessels for Stationary Service (A 70 – 35 T), submitted by Committee A-1 on Steel,

Carbon-Steel and Alloy-Steel Castings for Railroads (A 87 – 35 T), submitted by Committee A-1,

Electric-Resistance-Welded Steel and Open-Hearth Iron Boiler Tubes (A 178 – 35 T), submitted by Committee A-1,

Seamless Cold-Drawn Steel Heat-Exchanger and Condenser Tubes (A 179 – 35 T), submitted by Committee A-1,

Carbon-Steel Castings for Miscellaneous Industrial Uses (A 180 – 35 T), submitted by Committee A-1,

Forged or Rolled Steel Pipe Flanges for General Service (A 181 – 35 T), submitted by Committee A-1,

Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for Service at Temperatures from 750 to 1100 F. (A 182 – 35 T), submitted by Committee A-1,

Heat-Treated Carbon-Steel and Alloy-Steel Track Bolts (A 183 – 35 T), submitted by Committee A-1,

24 per cent Chromium, 12 per cent Nickel Alloy Steel Castings (A 171 – 35 T), submitted by Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys,

25 per cent Chromium, 20 per cent Nickel Alloy Steel Castings (A 172 – 35 T), submitted by Committee A-10,

28 per cent Chromium, 9 per cent Nickel Alloy Steel Castings (A 173 – 35 T), submitted by Committee A-10,

20 per cent Nickel, 9 per cent Chromium Alloy Steel Castings (A 174 – 35 T), submitted by Committee A-10,

35 per cent Nickel, 15 per cent Chromium Alloy Steel Castings (A 175 – 35 T), submitted by Committee A-10,

Soft Corrosion-Resisting Chromium Steels (Sheets, Flats, Strip) (A 176 – 35 T), submitted by Committee A-10, and

High-Strength Corrosion-Resisting Chromium-Nickel Steels (Sheets and Strips) (A 177 – 35 T), submitted by Committee A-10.

Tentative Methods of:

Test for Vapor Pressure of Motor and Aviation Gasoline (Reid Method) (D 417 – 35 T), submitted by Committee D-2 on Petroleum Products and Lubricants,

Surveying and Sampling Soils for Use in Place as Subgrades for Highways (D 420 – 35 T), submitted by Committee D-4 on Road and Paving Materials,
Preparing Soil Samples as Received from the Field for Mechanical Analysis and the Determination of the Subgrade Soil Constants (D 421 – 35 T), submitted by Committee D-4,
Mechanical Analysis of Soils (D 422 – 35 T), submitted by Committee D-4,
Test for Liquid Limit of Soils (D 423 – 35 T), submitted by Committee D-4,
Test for Plastic Limit and Plasticity Index of Soils (D 424 – 35 T), submitted by Committee D-4,
Test for Centrifuge Moisture Equivalent of Soils (D 425 – 35 T), submitted by Committee D-4,
Test for Field Moisture Equivalent of Soils (D 426 – 35 T), submitted by Committee D-4,
Test for Shrinkage Factors of Soils (D 427 – 35 T), submitted by Committee D-4,
Testing Pile Floor Covering (D 418 – 35 T), submitted by Committee D-13 on Textile Materials,
Testing Fineness of Wool (D 419 – 35 T), submitted by Committee D-13,
Test for Accelerated Aging of Vulcanized Rubber (D 428 – 35 T), submitted by Committee D-11 on Rubber Products,
Test for Adhesion of Vulcanized Rubber to Metal (D 429 – 35 T), submitted by Committee D-11,
Flexing Tests for Rubber Products (D 430 – 35 T), submitted by Committee D-11,
Quantitative Spectrochemical Analysis of High Grade Pig Lead for Copper, Bismuth, Silver, and Nickel (E 25 – 35 T), submitted by Committee E-2 on Spectrographic Analysis,
Quantitative Spectrochemical Analysis of Zinc for Lead, Iron and Cadmium (E 26 – 35 T), submitted by Committee E-2, and
Quantitative Spectrochemical Analysis of Zinc Alloy Die Castings for Minor Constituents and Impurities (E 27 – 35 T), submitted by Committee E-2.

Revisions of the following existing standards and tentative standards were approved by Committee E-10:

Standard Specifications for:

Steel for Bridges (A 7 – 34), submitted by Committee A-1 on Steel,
Steel for Buildings (A 9 – 34), submitted by Committee A-1,
Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 – 34), submitted by Committee A-1,
Structural Silicon Steel (A 94 – 33), submitted by Committee A-1, and
Round-Hole Screens for Testing Purposes (E 17 – 33), submitted by Committee E-1 on Methods of Testing.

Standard Method of:

Test for Gravity of Petroleum and Petroleum Products by Means of the Hydrometer (D 287 – 33), submitted by Committee D-2 on Petroleum Products and Lubricants.

Tentative Specifications for:

High Tensile Strength Carbon-Steel Plates for Pressure Vessels (Plates 2 in. and Under in Thickness) (A 149 – 35 T), submitted by Committee A-1 on Steel,
High Tensile Strength Carbon-Steel Plates for Fusion-Welded Pressure Vessels (Plates over 2 in. up to and Including 4 in. in Thickness) (A 150 – 35 T), submitted by Committee A-1,

Cold-Rolled Strip Steel (A 109 – 35 T), submitted by Committee A-1,
Alloy-Steel Castings for Valves, Flanges and Fittings for Service at Temperatures from 750 to 1100 F. (A 157 – 35 T), submitted by Committee A-1,
Seamless Alloy-Steel Pipe for Service at Temperatures from 750 to 1100 F. (A 158 – 35 T), submitted by Committee A-1,
Copper-Silicon Alloy Wire for General Purposes (B 99 – 35 T), submitted by Committee B-5 on Copper and Copper Alloys, Cast and Wrought,
Structural Clay Load-Bearing Wall Tile (C 34 – 35 T), submitted by Committee C-10 on Hollow Masonry Building Units,
Wood to be Used as Panels in Weather Tests of Paints and Varnishes (D 358 – 35 T), submitted by Committee D-1 on Preservative Coatings for Structural Materials,
Insulated Wire and Cable: Class A0, 30 per cent Hevea Rubber Compound (D 27 – 35 T), submitted by Committee D-11 on Rubber Products, and
Insulated Wire and Cable: Performance Rubber Compound (D 353 – 35 T), submitted by Committee D-11.

Tentative Methods of:

Chemical Analysis of Portland Cement (C 114 – 35 T), submitted by Committee C-1 on Cement,
Sampling and Testing Structural Clay Tile (C 112 – 35 T), submitted by Committee C-10 on Hollow Masonry Building Units,
Testing and Tolerances for Woolen Yarns (D 403 – 35 T), submitted by Committee D-13 on Textile Materials,
Testing and Tolerances for Worsted Yarns (D 404 – 35 T), submitted by Committee D-13, and
Verification of Testing Machines (E 4 – 35 T), submitted by Committee E-1 on Methods of Testing.

Tentative Definitions of:

Terms Relating to Petroleum (D 288 – 35 T), submitted by Committee D-2 on Petroleum Products and Lubricants, and
Terms Relating to Methods of Testing (E 6 – 35 T), submitted by Committee E-1 on Methods of Testing.

The withdrawal of the following standards was approved by Committee E-10:

Standard Specifications for:

Boiler and Firebox Steel for Stationary Service (A 70 – 33), on the recommendation of Committee A-1 on Steel, and
Carbon-Steel Castings for Railroads (A 87 – 27), on the recommendation of Committee A-1.

PROMOTION AND EXPANSION OF STANDARDIZATION ACTIVITIES

Of the several subjects referred to in the 1935 report[1] of the committee as having been suggested for development in the Society, the subject of soap and other detergents has reached a point where a standing committee has been authorized and organization is being effected at the present annual meeting. The committee on paper and allied products will probably be organized within the next few months. The organization of such a committee has been authorized and a special group has been appointed which is looking into the scope and activities to be covered and the selection of a suitable personnel. In this work of organization the Society has cooperated closely with the Technical Association of the Pulp and Paper Industry.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 517 (1935).

Considerable interest has been shown in the subject of heat insulating materials. Due to the increased use of such materials in dwelling construction a definite need has developed for adequate standard methods of test to determine not only the heat insulating value of the various materials offered but also to cover other very important properties of such materials. Committee E-10 will look into the possibilities of this field during the coming year.

The subject of plastics and synthetic resins has been under discussion for several years. Considerable interest was shown at a meeting devoted to this subject sponsored by the New York District Committee on April 21, 1936, and Committee E-6 on Papers and Publications has before it a suggestion that a more formal symposium on this subject be arranged either at a regional meeting of the Society or at a session at a future annual meeting. Materials of this general type are finding increasing use in mechanical applications and since the several materials vary considerably in mechanical properties it is desirable that adequate tests be established in order to determine the suitability of the materials for different uses.

RELATIONS WITH AMERICAN STANDARDS ASSOCIATION

Standards Submitted Under Proprietary Sponsorship Procedure.—The proprietary sponsorship procedure for submitting standards to the American Standards Association is particularly appropriate for a large number of A.S.T.M. standards. A number of standing committees now have under consideration the submission of existing A.S.T.M. standards to the A.S.A. under this method. The following standards have been approved during the year by the A.S.A. as American standards:

Standard Specifications for:

Billet-Steel Concrete Reinforcement Bars (A 15 – 35) (A.S.A. No. A50.1-1936),
Rail-Steel Concrete Reinforcement Bars (A 16 – 35) (A.S.A. No. A50.2-1936),
Cold-Drawn Steel Wire for Concrete Reinforcement (A 82 – 34) (A.S.A. No. A50.3-1936),
Structural Rivet Steel (A 141 – 33) (A.S.A. No. G21-1936),
Steel for Bridges (A 7 – 34) (A.S.A. No. G18-1936), and
Mild Steel Plates (A 10 – 34) (A.S.A. No. G20-1936).

Standard Methods of:

Chemical Analysis of Manganese Bronze (B 27 – 35) (A.S.A. No. K3-1935),
Routine Analysis of Dry Red Lead (D 49 – 35) (A.S.A. No. K16.1-1935),

Test for Cubic Foot Weight of Crushed Bituminous Coal (D 291 – 29) (A.S.A. No. K20.1-1936),
Test for Cubic Foot Weight of Coke (D 292 – 29) (A.S.A. No. K20.2-1936),
Tumbler Test for Coke (D 294 – 29) (A.S.A. No. K20.3-1936),
Shatter Test for Coke (D 141 – 23) (A.S.A. No. K20.4-1936),
Test for Volume of Cell Space of Lump Coke (D 167 – 24) (A.S.A. No. K20.5-1936), and
Test for Determination of Toluol Insoluble Matter in Rosin (Chiefly Sand, Chips, Dirt and Bark) (D 269 – 30) (A.S.A. No. K21.1-1936).

Recommended Practice for:

Thermal Analysis of Steel (E 14 – 33) (A.S.A. No. Z30.2-1936).

Standards Submitted Under Sectional Committee Procedure.—Reports have been received from several of the sectional committees for which the Society is sponsor, submitting standards to the A.S.A. for approval. These reports have been transmitted to that association and the following standards have been approved during the year:

On the Recommendation of Sectional Committee B36 on Standardization of Dimensions and Material of Wrought-Iron and Wrought-Steel Pipe and Tubing:

Approved as American Standards:

Standard Specifications for Electric-Resistance-Welded Steel Pipe (A 135 – 34) (A.S.A. No. B36.5-1935),
Standard Specifications for Forge-Welded Steel Pipe (A 136 – 34) (A.S.A. No. B36.6-1935),
Standard Specifications for Lock-Bar Steel Pipe (A 137 – 34) (A.S.A. No. B36.7-1935), and
Standard Specifications for Riveted Steel and Wrought-Iron Pipe (A 138 – 34) (A.S.A. No. B36.8-1935).

Approved as American Tentative Standards:

Tentative Specifications for Lap-Welded and Seamless Steel Pipe for High-Temperature Service (A 106 – 34 T) (A.S.A. No. B36.3-1935), and
Tentative Specifications for Electric-Fusion-Welded Steel Pipe (Sizes 8 in. to but not Including 30 in.) (A 139 – 34 T) (A.S.A. No. B36.9-1935).

On the Recommendation of Sectional Committee G8 on Specifications for Zinc Coating of Iron and Steel:

Approved as American Standards:

Standard Specifications for Zinc-Coating (Galvanized) Iron or Steel Telephone and Telegraph Line Wire (A 111 – 33) (A.S.A. No. G8.3-1935),
Standard Specifications for Zinc-Coated (Galvanized) Iron or Steel Tie Wires (A 112 – 33) (A.S.A. No. G8.4-1935),
Standard Specifications for Zinc-Coated Iron or Steel Chain-Link Fence Fabric Galvanized After Weaving (A 117 – 33) (A.S.A. No. G8.5-1935), and
Standard Specifications for Zinc-Coated (Galvanized) Iron or Steel Wire Strand (Cable) (A 122 – 33) (A.S.A. No. G8.6-1935).

Approved as American Tentative Standard:

Tentative Specifications for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses (A 120 – 34 T) (A.S.A. No. G8.7-1935).

On the Recommendation of Sectional Committee L3 on Specifications for Rubber-Lined Fire Hose:

Approved as American Standard:

Standard Specifications for Cotton Rubber-Lined Fire Hose for Public and Private Fire Department Use (D 296 – 35) (A.S.A. No. L3-1935).

On the Recommendation of Sectional Committee Z11 on Petroleum Products and Lubricants:

Approved as American Standards:

Standard Method of Test for Water and Sediment in Petroleum Products by Means of Centrifuge (D 96 – 35) (A.S.A. No. Z11.8-1935),

Standard Method of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (D 86 – 35) (A.S.A. No. Z11.10-1935),

Standard Method of Test for Dilution of Crankcase Oils (D 322 – 35) (A.S.A. No. Z11.29-1935),

Standard Method of Test for Precipitation Number of Lubricating Oils (D 91 – 35) (A.S.A. No. Z11.30-1935),

Standard Method of Test for Distillation of Crude Petroleum (D 285 – 33) (A.S.A. No. Z11.32-1935), and

Standard Methods of Sampling Petroleum and Petroleum Products (D 270 – 33) (A.S.A. No. Z11.33-1935).

Approved as American Tentative Standards:

Tentative Definitions of Terms Relating to Petroleum (D 288 – 35 T) (A.S.A. No. Z11.28-1935),

Tentative Method of Test for Color of Lubricating Oils by Means of A.S.T.M. Union Colorimeter (D 155 – 34 T) (A.S.A. No. Z11.34-1935),

Tentative Method of Test for Color of Refined Petroleum Oil by Means of Saybolt Chromometer (D 156 – 34 T) (A.S.A. No. Z11.35-1935),

Tentative Method of Test for Gum Content of Gasoline (D 381 – 34 T) (A.S.A. No. Z11.36-1935),

Tentative Method of Test for Knock Characteristics of Motor Fuels (D 357 – 34 T) (A.S.A. No. Z11.37-1935),

Tentative Method of Test for Sulfur in Petroleum Oils by Lamp Method (D 90 – 34 T) (A.S.A. No. Z11.38-1935), and

Tentative Standard Viscosity-Temperature Chart for Liquid Petroleum Products (D 341 – 32 T) (A.S.A. No. Z11.39-1935).

New Committees Organized.—Mention was made in the 1935 report that authorization had been given for the Society to organize a new Sectional Committee on Petroleum Products and Lubricants with the A.S.T.M. as sole sponsor. The organization of this committee has been effected during the year with some thirty national societies represented on the new committee. The work of the former Sectional Committees on Methods of Testing Petroleum Products and Lubricants and on Specifications for Fuel Oils (Including Diesel Fuel) will be taken over by the new committee.

A committee of considerable interest to the Society has been organized during the year by the Standards Council of the American Standards Association, namely, the Mechanical Standards Committee. This committee will function under the Standards Council in reviewing all matters referred to the Council in the mechanical field. Mr. H. H. Morgan has been designated as the Society's representative on the Mechanical Standards Committee with the Assistant Secretary as alternate.

The Society has recently appointed a representative on the Sectional Committee on Standardization of Plumbing Equipment in view of the fact that the committee is now working on materials specifications of interest to the A.S.T.M. Mr. J. D. Stoddard has been designated as the Society's representative with Mr. P. J. Smith of the A.S.T.M. staff as alternate.

Respectfully submitted on behalf of the committee,

CLOYD M. CHAPMAN,
Chairman.

C. L. WARWICK,
Ex-officio Secretary.

A.S.T.M.
TENTATIVE STANDARDS

ISSUED OR REVISED, 1936

The term Tentative Standard is applied to a proposed Standard which is printed for one or more years with a view of eliciting criticism, of which the committee concerned will take due cognizance before recommending final action toward its adoption as standard.

Members of the Society and others are invited to direct written criticisms of any of these Tentative Revisions to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

TENTATIVE SPECIFICATIONS
FOR
STRUCTURAL NICKEL STEEL[1]

A.S.T.M. Designation: A 8 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1936.

Scope

1. These specifications cover high-strength structural nickel steel plates, shapes and bars up to $1\frac{1}{4}$ in., inclusive, in thickness, and eyebars up to 2 in. in thickness; intended primarily for special use as main stress-carrying material of structural members.

Process

2. The steel shall be made by either or both of the following processes: open-hearth or electric-furnace.

Discard

3. A sufficient discard shall be made from each ingot to secure freedom from injurious piping and undue segregation.

Chemical Composition

4. The steel shall conform to the following requirements as to chemical composition:

	LADLE ANALYSIS	CHECK ANALYSIS
Carbon, max., per cent	0.43	0.45
Manganese, max., per cent	0.80	0.85
Phosphorus, max., per cent	0.04	0.05
Sulfur, max., per cent	0.05	0.063
Nickel, per cent	3.00 to 4.00	3.00 to 4.00
Copper, when copper steel is specified, min., per cent	0.20	0.20

Ladle Analyses

5. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus, sulfur and nickel; also copper, when copper steel is specified. This analysis shall be made from a test ingot taken during the pouring of the melt. The

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee A-1 on Steel.

These specifications are in effect a revision of and replace the former Standard Specifications for Structural Nickel Steel (A 8 – 29), which standard was accordingly discontinued in 1936.

chemical composition thus determined shall be reported to the purchaser or his representative and shall conform to the requirements for ladle analysis specified in Section 4.

Check Analyses

6. Analyses may be made by the purchaser from finished material representing each melt. The chemical composition thus determined shall conform to the requirements for check analysis specified in Section 4.

Tension Tests

7. (*a*) The material shall conform to the following requirements as to tensile properties:

Tensile strength, lb. per sq. in.	90 000 to 115 000
Yield point, min., lb. per sq. in.	0.5 tens. str.
but in no case less than	55 000
Elongation in 8 in., min., per cent	$\frac{1\,600\,000}{\text{tens. str.}}$ [a]
Elongation in 2 in., min., per cent	$\frac{1\,700\,000}{\text{tens. str.}}$ [b]
Reduction of area, min., per cent	30 [c]

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[a] See Section 8.
[b] When specimen shown in Fig. 2 is used; see Section 11 (*d*).
[c] See Section 9.

(*b*) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine.

(*c*) *Tests of Eyebars.*—Full-size tests of annealed eyebars shall conform to the following requirements as to tensile properties:

Tensile strength, lb. per sq. in.	85 000 to 100 000
Yield point, min., lb. per sq. in.	48 000
Elongation in 18 ft., min., per cent	10
Reduction of area, min., per cent	30

The yield point in full-size tests of annealed eyebars shall be determined by the halt in the gage of the testing machine.

Modifications in Elongation

8. (*a*) For material over $\frac{3}{4}$ in. in thickness or diameter, a deduction from the percentage of elongation in 8 in. specified in Section 7 (*a*) of 0.25 per cent shall be made for each increase of $\frac{1}{16}$ in. of the specified thickness or diameter above $\frac{3}{4}$ in. to a minimum of 14 per cent.

(*b*) For material under $\frac{5}{16}$ in. in thickness or diameter, a deduction from the percentage of elongation in 8 in. specified in Section 7 (*a*) of 1.25 per cent, shall be made for each decrease of $\frac{1}{32}$ in. of the specified thickness or diameter below $\frac{5}{16}$ in.

Modification in Reduction of Area

9. For material over $\frac{3}{4}$ in. in thickness or diameter, a deduction from the percentage of reduction of area specified in Section 7 (*a*) of 0.50 per

cent shall be made for each increase of $\frac{1}{16}$ in. of the specified thickness or diameter above $\frac{3}{4}$ in.

Bend Tests

10. Bend test specimens shall stand being bent cold through 180 deg. without cracking on the outside of the bent portion around a pin the diameter of which shall have the following relation to the thickness of the specimen:

THICKNESS OF MATERIAL	RATIO: PIN DIAMETER / THICKNESS OF SPECIMEN
Up to $\frac{3}{4}$ in., incl.	$1\frac{1}{2}$
Over $\frac{3}{4}$ to $1\frac{1}{4}$ in., incl.	2
Over $1\frac{1}{4}$ to 2 in., incl.	$2\frac{1}{2}$

Test Specimens

11. (*a*) Test specimens shall be prepared for testing from the material in its rolled condition.

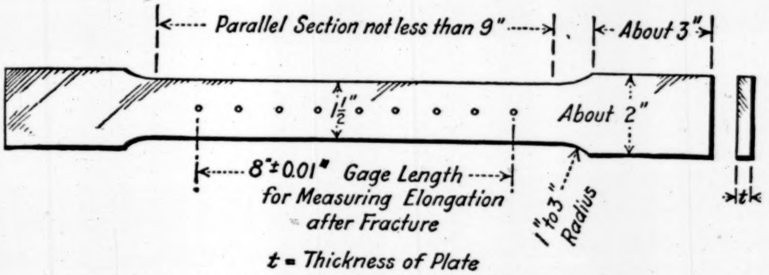
Parallel Section not less than 9"
About 3"
$\frac{1}{2}$"
About 2"
8"±0.01" Gage Length for Measuring Elongation after Fracture
1" to 3" Radius
t
t = Thickness of Plate

FIG. 1.—Standard 8-in. Gage Length Test Specimen.

(*b*) Test specimens shall be taken longitudinally and, except as specified in Paragraphs (*d*) and (*e*), shall be of the full thickness or section of material as rolled.

(*c*) Test specimens for plates, shapes and flats may be machined to the form and dimensions shown in Fig. 1, or with both edges parallel.

(*d*) Tension test specimens for eyebar flats over $1\frac{1}{2}$ in. in thickness may be machined to a thickness or diameter of at least $\frac{3}{4}$ in. for a length of at least 9 in. or they may conform to the dimensions shown in Fig. 2.

(*e*) Bend test specimens for eyebar flats over $1\frac{1}{2}$ in. in thickness may be $\frac{1}{2}$ in. square in section.

(*f*) The machined sides of rectangular bend test specimens may have the corners rounded to a radius not over $\frac{1}{16}$ in.

Number of Tests

12. (*a*) Two tension and two bend tests shall be made from each melt, unless the finished material from a melt is less than 30 tons when one tension and one bend test will be sufficient. If, however, material from one melt differs $\frac{3}{8}$ in. or more in thickness, one tension and one bend test shall be made from both the thickest and thinnest material rolled regardless of the weight represented.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(*c*) If the percentage of elongation of any tension test specimen is less than that specified in Section 7 (*a*) and any part of the fracture is more than $\frac{3}{4}$ in. from the center of the gage length of a 2-in. specimen or is outside the middle third of the gage length of an 8-in. specimen, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

Permissible Variations in Weight and Thickness

13. (*a*) One cubic inch of rolled steel is assumed to weigh 0.2833 lb. The cross-sectional area or weight of each structural-size shape and of each universal mill plate up to and including 36 in. in width shall not vary more than 2.5 per cent from the theoretical or specified amounts. The thickness or weights of rectangular sheared mill plates and of rectangular universal mill plates over 36 in. in width shall conform to the requirements of Paragraphs (*b*) and (*c*).

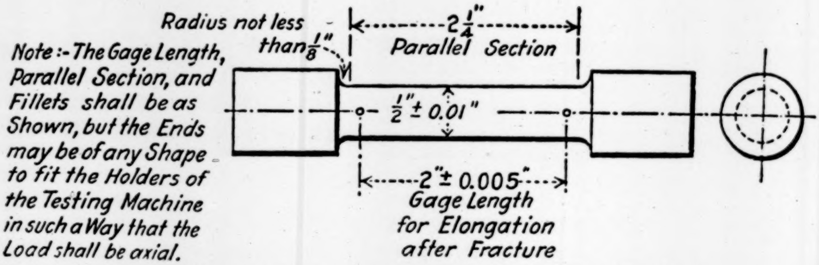
Radius not less than $\frac{1}{8}$"
$2\frac{1}{4}$"
Parallel Section
Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.
$\frac{1}{2}$" ± 0.01"
2" ± 0.005"
Gage Length for Elongation after Fracture

FIG. 2.—Standard 2-in. Gage Length Tension Test Specimen.

(*b*) *Plates, When Ordered to Weight per Square Foot.*—The weight of each lot[1] of plates in each shipment shall not vary from the weight ordered more than the amount given in Table I.

(*c*) *Plates, When Ordered to Thickness.*—The thickness of each plate shall not vary more than 0.01 in. under that ordered.

The overweight of each lot[1] of plates in each shipment shall not exceed the amount given in Table II.

Finish

14. The finished material shall be free from injurious defects and shall have a workmanlike finish.

Marking

15. The name or brand of the manufacturer and the melt number shall be legibly stamped or rolled on all finished material. The melt

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[1] The term "lot" as applied to Table I means all of the plates of each group width and group weight; as applied to Table II, it means all the plates of each group width and group thickness.

TABLE I.—PERMISSIBLE VARIATIONS OF RECTANGULAR PLATES ORDERED TO WEIGHT.

Ordered Weight, lb. per sq. ft.	Permissible Variations in Average Weights per Square Foot of Plates for Widths Given, Expressed in Percentages of Ordered Weights																		Ordered Weight, lb. per sq. ft.
	Under 48 in.		48 to 60 in., excl.		60 to 72 in., excl.		72 to 84 in., excl.		84 to 96 in., excl.		96 to 108 in., excl.		108 to 120 in., excl.		120 to 132 in., excl.		132 in. or over		
	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	
7.5 to 10, excl.	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	...	...	...	...	7.5 to 10, excl.
10 to 12.5, excl.	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	9	3	10 to 12.5, excl.
12.5 to 15, excl.	3	2.5	3.5	2.5		3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	12.5 to 15, excl.
15 to 17.5, excl.	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	15 to 17.5, excl.
17.5 to 20, excl.	2.5	2	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	17.5 to 20, excl.
20 to 25, excl.	2	2	2.5	2	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	20 to 25, excl.
25 to 30, excl.	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	4.5	3	5	3	25 to 30, excl.
30 to 40, excl.	2	2	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	4.5	3	30 to 40, excl.
40 to 51, incl.	2	2	2	2	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	40 to 51, incl.

NOTE.—The weight per square foot of individual plates shall not vary from the ordered weight by more than one and one-third the amount given in this table.

TABLE II.—PERMISSIBLE OVERWEIGHTS OF RECTANGULAR PLATES ORDERED TO THICKNESS.

Ordered Thickness, in.	Permissible Excess in Average Weights per Square Foot of Plates for Widths Given, Expressed in Percentages of Nominal Weights									Ordered Thickness, in.
	Under 48 in.	48 to 60 in., excl.	60 to 72 in., excl.	72 to 84 in., excl.	84 to 96 in., excl.	96 to 108 in., excl.	108 to 120 in., excl.	120 to 132 in., excl.	132 in. or over	
$\frac{3}{16}$ to $\frac{1}{4}$, excl.	7	8	9	10	12	..	..	..	..	$\frac{3}{16}$ to $\frac{1}{4}$, excl.
$\frac{1}{4}$ to $\frac{5}{16}$, excl.	6	7	8	9	10	12	14	16	19	$\frac{1}{4}$ to $\frac{5}{16}$, excl.
$\frac{5}{16}$ to $\frac{3}{8}$, excl.	5	6	7	8	9	10	12	14	17	$\frac{5}{16}$ to $\frac{3}{8}$, excl.
$\frac{3}{8}$ to $\frac{7}{16}$, excl.	4.5	5	6	7	8	9	10	12	15	$\frac{3}{8}$ to $\frac{7}{16}$, excl.
$\frac{7}{16}$ to $\frac{1}{2}$, excl.	4	4.5	5	6	7	8	9	10	13	$\frac{7}{16}$ to $\frac{1}{2}$, excl.
$\frac{1}{2}$ to $\frac{5}{8}$, excl.	3.5	4	4.5	5	6	7	8	9	11	$\frac{1}{2}$ to $\frac{5}{8}$, excl.
$\frac{5}{8}$ to $\frac{3}{4}$, excl.	3	3.5	4	4.5	5	6	7	8	9	$\frac{5}{8}$ to $\frac{3}{4}$, excl.
$\frac{3}{4}$ to 1, excl.	2.5	3	3.5	4	4.5	5	6	7	8	$\frac{3}{4}$ to 1, excl.
1 to $1\frac{1}{4}$, incl.	2.5	2.5	3	3.5	4	4.5	5	6	7	1 to $1\frac{1}{4}$, incl.

NOTE.—The weight of individual plates ordered to thickness shall not exceed the nominal weight by more than one and one-third the amount given in this table.

number shall be legibly marked, by stamping if practicable, on each test specimen.

Inspection

16. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection

17. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 6 shall be reported within five working days from the receipt of samples.

(*b*) Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing

18. Samples tested in accordance with Section 6, which represent rejected material, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS

FOR

HIGH-STRENGTH STRUCTURAL RIVET STEEL[1]

A.S.T.M. Designation: A 195 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1936.[2]

Scope

1. These specifications cover a rivet steel which with proper riveting technique is suitable for use with structural silicon steel, as prescribed in the Standard Specifications for Structural Silicon Steel (A.S.T.M. Designation: A 94) of the American Society for Testing Materials,[3] and equivalent steels.

Process

2. The steel shall be made by either or both of the following processes: open-hearth or electric-furnace.

Annealing

3. Bars to be manufactured into rivets by the cold-heading process shall first be annealed by heating to 1450 F. (788 C.) and cooled slowly in the furnace or in still air. Bars to be manufactured into rivets by the hot-heading process need not be annealed.

Chemical Composition

4. (*a*) The steel shall conform to the following requirements as to chemical composition:

		Ladle Analysis	Check Analysis
Carbon, max., per cent		0.30	0.35
Manganese, max., per cent		1.65	1.75
Phosphorus, max., per cent	Acid	0.06	0.075
	Basic	0.04	0.05
Sulfur, max., per cent		0.05	0.063
Silicon, max., per cent		0.25	0.30
Copper, when copper steel is specified, min., per cent		0.20	0.18

(*b*) If it be desired to obtain the specified physical properties by the addition of alloying elements other than silicon and manganese, the chemical composition shall be agreed upon between the manufacturer and the purchaser.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee A-1 on Steel.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 26, 1936.

[3] 1936 Book of A.S.T.M. Standards, Part I, p. 34.

Ladle Analyses

5. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus, sulfur and silicon; also copper, when copper steel is specified. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and the percentages of carbon, manganese, phosphorus, sulfur and silicon; also copper, when copper steel is specified, shall conform to the requirements for ladle analysis specified in Section 4 (*a*). Where alloying elements other than silicon and manganese have been agreed upon by the manufacturer and the purchaser such elements shall be reported in the analysis.

Check Analyses

6. Analyses may be made by the purchaser from finished material representing each melt. The percentages of carbon, manganese, phosphorus, sulfur, silicon; also copper, when copper steel is specified, thus determined shall conform to the requirements for check analysis specified in Section 4 (*a*). Where alloying elements other than silicon and manganese have been agreed upon by the manufacturer and the purchaser such elements shall be reported in the analysis.

Tension Tests

7. (*a*) The tension test specimens, after annealing as prescribed in Section 9 (*b*), shall conform to the following requirements as to tensile properties:

Tensile Strength, lb. per sq. in.		70 000 to 85 000
Yield Point, lb. per sq. in.	min	0.5 tens. str.
	but in no case less than	38 000
Elongation in 8 in., per cent	min	$\frac{1\,600\,000}{\text{tens. str.}}$
	but in no case less than	20

(*b*) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine.

Upsetting Test

8. Specimens cut to a length of one and one-fourth times the diameter of the bar shall stand hammering down cold in a longitudinal direction to a length equal to three-fourths of the original diameter, without showing seams or other defects which would tend to produce defects in the manufactured rivets.

Test Specimens

9. (*a*) Test specimens shall be of the full diameter of the bars as rolled.

(*b*) Specimens for the tension tests (Section 7 (*a*)) shall be annealed by heating to 1450 F. (788 C.), holding at this temperature for not less than 30 min., and cooling slowly in the furnace. The physical test requirements specified in Section 7 (*a*) shall apply to specimens thus annealed.

(*c*) Specimens for the upsetting test (Section 8) shall not be annealed, but shall be representative of the condition of the bars as rolled.

Number of Tests

10. (*a*) Two tension tests shall be made from each melt, unless the finished material from a melt is less than 30 tons when one tension test will be sufficient. If, however, bars from one melt differ $\frac{1}{4}$ in. or more in diameter, one tension test shall be made on bars of both the greatest and least diameters rolled, regardless of the weight represented.

(*b*) One upsetting test shall be made on bars of each size rolled from each melt.

(*c*) If any tension test specimen develops flaws, it may be discarded and another specimen substituted.

Retests

11. If the percentage of elongation of any tension test specimen is less than that specified in Section 7 (*a*) and any part of the fracture is outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

Permissible Variations in Diameter

12. The diameter of rivet bars shall not vary from the size ordered by more than the amounts given in the following table:

DIAMETER SPECIFIED, IN.		PERMISSIBLE VARIATIONS IN DIAMETER, IN.		
OVER	TO AND INCLUDING	UNDER	OVER	OUT OF ROUND
...	$\frac{5}{16}$	0.007	0.007	0.010
$\frac{5}{16}$	$\frac{7}{16}$	0.007	0.007	0.011
$\frac{7}{16}$	$\frac{5}{8}$	0.008	0.008	0.012
$\frac{5}{8}$	$\frac{7}{8}$	0.009	0.009	0.014
$\frac{7}{8}$	1	0.010	0.010	0.015
1	$1\frac{1}{8}$	0.012	0.012	0.016
$1\frac{1}{8}$	$1\frac{1}{4}$	0.014	0.014	0.018
$1\frac{1}{4}$	$1\frac{3}{8}$	0.016	0.016	0.022
$1\frac{3}{8}$	$1\frac{1}{2}$	0.018	0.018	0.026
$1\frac{1}{2}$	2	0.022	0.022	0.030

Finish

13. The finished bars shall be free from injurious defects and shall have a workmanlike finish.

Marking

14. Rivet bars shall, when loaded for shipment, be properly separated and marked with the name or brand of the manufacturer and the melt number for identification. The melt number shall be legibly marked on each test specimen.

Inspection

15. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the bars ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the bars are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection

16. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 6 shall be reported to the manufacturer within five working days from the receipt of samples.

(*b*) Bars which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing

17. Samples tested in accordance with Section 6, which represent rejected bars, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS
FOR
FABRICATED STEEL BAR OR ROD MATS FOR CONCRETE REINFORCEMENT[1]

A.S.T.M. Designation: A 184 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1936.

Scope

1. These specifications cover materials for concrete reinforcement in mat (or sheet) form fabricated from steel bars (which term shall hereinafter include steel rods). Such mats shall consist of two layers of bars which are assembled at right angles to each other and clipped or welded at all or part of the intersections to form a rectangular grid.

Basis of Purchase

2. The purchaser shall specify the following:

(*a*) Which of the three types of bar material listed in Section 3 shall be used in fabricating the mats,

(*b*) In case new billet or axle steel is specified, which of the grades is required, that is, structural, intermediate or hard grade,

(*c*) Whether deformed or plain bars are required, and

(*d*) Whether clipped or welded mats are required.

Note.—For welded mats, hard grades of billet or axle steel or rail steel should not be specified.

Bar Material

3. Steel bars entering into the manufacture of mats shall conform to one of the following types before fabrication:

(*a*) Deformed or plain bars of new billet steel conforming to the Standard Specifications for Billet-Steel Concrete Reinforcement Bars (A.S.T.M. Designation: A 15) of the American Society for Testing Materials.[2]

(*b*) Deformed or plain bars of rail steel conforming to the Standard

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee A-1 on Steel.

[2] 1936 Book of A.S.T.M. Standards, Part I, p. 95.

Specifications for Rail-Steel Concrete Reinforcement Bars (A.S.T.M. Designation: A 16) of the American Society for Testing Materials.[1]

(*c*) Deformed or plain bars of axle steel conforming to the Standard Specifications for Axle-Steel Concrete Reinforcement Bars (A.S.T.M. Designation: A 160) of the American Society for Testing Materials.[2]

Test Reports on Bar Material

4. The fabricator shall supply test reports showing that the bar stock used in the fabrication of the mats as delivered has fulfilled the tensile and bend test requirements of the specified type and grade as described in Section 3, which reports shall show the manufacturer's test identification numbers, including the identity of the stock.

Clips

5. Clips for clipped mats shall be formed mechanically prior to or during the fabrication and assembly of the mats. They may be of the form and type furnished by the fabricator provided they engage and attach both bars at any intersection in such manner that separation in normal handling is prevented and the assembly conforms to the requirements hereinafter specified for physical tests of attachment at intersections.

Fabrication

6. Fabricated mats shall be composed of two layers of bars substantially perpendicular to each other. Bars in each layer shall be substantially parallel. Mats shall be fabricated in a manner that assures against appreciable dislodgement of the bars during handling, shipping, placing and concreting.

Assembly

7. Mats shall be assembled by means of clipping or welding which provides attachment at all exterior intersections and at not less than alternate interior intersections.

Welds

8. Welds at the intersections shall be made in a workmanlike manner and shall be of such quality as not to break apart in normal handling prior to installation of the mats. The number and distribution of sound welds shall be not less than that required in Section 7, provided, however, that when welds are made at every intersection, the separation of 10 per cent or less of all welds, not more than one-half of the permissible maximum number of which separated welds shall be located on any one member, shall not be cause for rejection. Welding shall be done in such a manner that the minimum requirements for tensile strength and yield point of bar stock as described in Section 3 shall be met when a specimen is tested

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[1] 1936 Book of A.S.T.M. Standards, Part I, p. 100.

[2] *Ibid.*, p. 103.

across points of weld, provided, however, that in the event of special field or other tests after fabrication, failure to conform to the provisions of the specification covering steel bars as to percentage of elongation shall not be cause for rejection when samples are tested across any point of weld.

Size and Spacing Dimensions

9. The sizes, spacing and arrangement of bars in mats shall conform to the design specified by the purchaser. Bars shall extend beyond exterior intersections a distance of not less than 1 in.

Spacing of Bars

10. The spacing of bars shall average that specified in the design and the space between individual bars shall not vary more than 1 in. from that specified.

Widths and Lengths of Mats

11. The over-all length or width of the mats shall not be more than 1 in. greater or less than the specified dimension. Unless otherwise specified, lengths of mats shall not exceed 16 ft. Widths of mats shall preferably not exceed 9 ft. 8 in.

Physical Properties

12. It shall be considered satisfactory compliance with these specifications if connections made by clipping shall be capable of withstanding a static load of 75 lb. exerted in the direction of either bar, with not more than $\frac{1}{2}$ in. slip; and, on either clipped or welded mats, a static load of 150 lb. exerted perpendicular to the plane of the mat tending to separate the bars, with no apparent loosening when applied to one intersection of bars.

Physical Tests

13. (*a*) Tests of the degree of attachment of bars by clipping or welding at intersections shall be made on the mats designated in Section 14 and in accordance with the methods described in Paragraphs (*b*) and (*c*). Not less than one exterior and one interior connection in each designated mat shall be tested in order to establish the adequacy of attachment and at the option of the inspector additional connections in the same mat may also be tested.

(*b*) Tests of connections against slipping may be performed on one intersection in an assembled mat by means of a spring balance.

(*c*) Tests of connections against bar separation may be performed on an assembled mat by placing blocks under a bar in the upper layer and applying sufficient weight on the perpendicular bar in the lower layer.

Number of Tests and Measurements

14. Two mats of each type in any order shall be tested in accordance with Sections 12 and 13 and measured for over-all dimensions and bar

spacings provided, however, that where there are more than 1000 mats of a single type in an order, one mat of such type shall be so tested and measured for each 500 mats, or fraction thereof, in the total order. Inspection as to general workmanship shall be visual.

Retests

15. In the case of retests after rejection, twice the number of samples specified in Sections 13 (*a*) and 14 shall be selected and tested. All such samples shall meet the requirements of these specifications.

Finish

16. The finished mats shall be free from injurious defects in material or workmanship and shall be suitably flat for use.

Marking

17. One of more mats in each consignment shall be marked with tags showing the name of the fabricator and other marking to identify it with the order.

Inspection

18. The inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed, to all parts of the fabricator's plant which concern the fabrication of the mats ordered. The fabricator shall afford the inspector, without charge, all reasonable facilities to satisfy him that the mats are being furnished in accordance with these specifications. All tests and inspection shall be made at the place of fabrication prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with fabricating operations.

Rejection

19. Fabricated mats which do not meet the requirements of these specifications shall be rejected. Unless otherwise specified, any rejection shall be reported within 5 days from the time of selection of test samples.

Rehearing

20. Rejected materials may be preserved for a period of two weeks from the date of inspection during which time the fabricator may make claim for a rehearing and retesting if dissatisfied with the results of the original tests.

Reconditioning

21. Fabricated mats which are finally rejected as not meeting the requirements of these specifications may be reassembled and subjected to reinspection provided that the qualities of the individual bars and of the fabricated mats are not injured through such process.

TENTATIVE SPECIFICATIONS

FOR

WELDED STEEL WIRE FABRIC FOR CONCRETE REINFORCEMENT[1]

A.S.T.M. Designation: A 185 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1936.

Scope

1. These specifications cover welded wire fabric to be used for the reinforcement of concrete.

Description

2. The term "welded wire fabric" as herein used designates a material composed of cold-drawn steel wires fabricated into sheet (or so-called "mesh") form by the process of electric welding. The finished material shall consist essentially of a series of longitudinal and transverse wires arranged substantially at right angles to each other and welded together at all points of intersection.

Grade of Wire

3. Wire used in the manufacture of welded wire fabric shall conform to the Standard Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement (A.S.T.M. Designation: A 82) of the American Society for Testing Materials.[2]

Fabrication

4. (*a*) The wires shall be assembled by automatic machines or by other suitable mechanical means which will assure accurate spacing and alignment of all members of the finished fabric.

(*b*) Longitudinal and transverse members shall be securely connected at every intersection by a process of electrical-resistance welding which employs the principle of fusion combined with pressure.

(*c*) Wire of proper grade and quality when fabricated in the manner herein required shall result in a strong, serviceable mesh-type product having substantially square or rectangular openings. It shall be fabricated and finished in a workmanlike manner, shall be free from injurious defects, and shall conform to these specifications.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee A-1 on Steel.

[2] 1936 Book of A.S.T.M. Standards, Part I, p. 107.

Tensile Properties

5. All wires of the finished fabric shall meet the minimum requirements for tensile properties and shall also withstand the bend test as prescribed for the wire before fabrication in the Standard Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement (A.S.T.M. Designation: A 82) of the American Society for Testing Materials.[1]

Tension Tests

6. (*a*) The minimum requirements for tensile strength, yield point, and reduction of area, shall be met when a specimen is tested in tension either across or between the welds.

(*b*) Reduction of area may be determined by measuring the ruptured section of a specimen which has been tested either across or between the welds. However, in the case of a specimen which has been tested across a weld, the measurement shall be made only when rupture has occurred at a sufficient distance from the center of the weld to permit an accurate measurement of the fractured section.

Bend Tests

7. The bend test shall be made on a specimen between the welds.

Test Specimens

8. (*a*) Test specimens shall be obtained by cutting from the finished fabric units of representative character and of suitable size to enable proper performance of the intended test.

(*b*) Specimens used for testing tensile properties across a weld shall have the welded joint located approximately at the center of the strand being tested, and the cross wire forming the welded joint shall extend approximately 1 in. beyond each side of the welded joint.

Number of Tests

9. (*a*) One tension and one bend test for each size of wire shall be made for each 75,000 sq. ft. of fabric or fraction thereof.

(*b*) If any test specimen shows defects or develops flaws, it may be discarded and another specimen substituted.

Gages, Spacings and Dimensions

10. Gages, spacings, arrangement of wires, and dimensions of units in flat sheet form or rolls shall conform to the requirements specified by the purchaser.

Width of Fabric

11. (*a*) The width of fabric shall be considered to be the center-to-center distance between outside longitudinal wires, unless otherwise specified.

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[1] 1936 Book of A.S.T.M. Standards, Part I, p. 107.

(*b*) Transverse wires shall project beyond the center of each outside longitudinal wire a distance of at least ½ in. and, unless otherwise specified, not more than 1 in.

Permissible Variations in Wire Diameter

12. The permissible variation in diameter of any wire in the finished fabric shall conform to the tolerances prescribed for the wire before fabrication in the Standard Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement (A.S.T.M. Designation: A 82) of the American Society for Testing Materials.[1]

Spacings

13. The average spacing of members shall be such that the total number contained in a sheet or roll is at least equal to that determined by the specific spacing, but the center-to-center distance between individual members may vary not more than ¼ in. from the specified spacing.

Over-all Dimensions

14. (*a*) The over-all length of flat sheets, measured on any member, shall not be more than 1 in. greater or less than the specified over-all length.

(*b*) In case the width of flat sheets or rolls is specified as the over-all width (tip-to-tip length of cross members), the width shall not be more than 1 in. greater or less than the specified width.

Rolls or Sheets

15. Welded wire fabric may be furnished either in flat sheets or in rolls as specified by the purchaser.

Bundling

16. (*a*) When fabric is furnished in flat sheets, it shall be assembled in bundles of convenient size containing not more than 20 sheets and securely fastened together.

(*b*) When fabric is furnished in rolls, each roll shall be secured so as to prevent unwinding during shipping and handling.

Marking

17. Each bundle of flat sheets and each roll shall have attached thereto a suitable tag bearing the name of the manufacturer, description of the material, and such other information as may be specified by the purchaser.

Inspection

18. (*a*) All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

(*b*) The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the fabric is being furnished in accordance with these specifications.

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[1] 1936 Book of A.S.T.M. Standards, Part I, p. 107.

Rejection

19. (*a*) Material which does not meet the requirements of these specifications may be rejected. Unless otherwise specified, any rejection shall be reported to the manufacturer within five days from the time of selection of test specimens.

(*b*) In case a specimen fails to meet the tension or bend test, the material shall not be rejected until two additional specimens, taken from other wires in the same sheet or roll, have been tested. The material shall be considered as meeting these specifications in respect to any prescribed tensile property, provided the tested average for the three specimens, including the specimen originally tested, is at least equal to the required minimum for the particular property in question and provided further that none of the three specimens develops less than 80 per cent of the required minimum for the tensile property in question. The material shall be considered as meeting these specifications in respect to bend test requirements, provided both additional specimens satisfactorily pass the prescribed bend test.

(*c*) Except as specified in Paragraph (*d*), any material which shows injurious defects subsequent to its acceptance at the manufacturer's works may be rejected and the manufacturer shall be promptly notified.

(*d*) Welded joints shall withstand normal shipping and handling without becoming broken; but the presence of broken welds, regardless of cause, shall not constitute cause for rejection unless the number of broken welds per sheet exceeds 4 per cent of the total number of joints in the sheet, or, if the material is furnished in rolls, 4 per cent of the total number of joints in 150 sq. ft. of fabric and, furthermore, provided not more than one-half the permissible maximum number of broken welds are located on any one member.

(*e*) In case rejection is justified either by reason of over-all dimension (Section 14) or by reason of broken welds (Paragraph (*d*)), the amount of material rejected shall be limited to those individual sheets or rolls in which the permissible variation in over-all dimension or the permissible number of broken welds is exceeded. If, however, the total number of sheets or rolls thus rejected exceeds 25 per cent of the total number in the shipment, then the entire shipment may be rejected.

Rehearing

20. Rejected materials shall be preserved for a period of at least two weeks from the date of inspection, during which time the manufacturer may make claim for a rehearing and retesting.

Retests

21. In the case of retests, after rejection, twice the number of specimens specified in Section 9 shall be tested and all such specimens shall meet the requirements of these specifications.

TENTATIVE SPECIFICATIONS

FOR

HIGH-CARBON-STEEL JOINT BARS[1]

A.S.T.M. Designation: A 5 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Adopted, 1913; Revised, 1914; Reissued as Tentative, 1936.

Scope

1. These specifications cover high-carbon-steel joint bars for general use in standard railroad tracks.

Process

2. The steel shall be made by either or both of the following processes: open-hearth or electric-furnace.

Discard

3. Sufficient discard shall be made from each ingot to insure freedom from piping and undue segregation.

Heating

4. Joint bars shall be uniformly heated for punching, slotting and shaping.

Chemical Composition

5. The steel shall conform to the following requirements as to chemical composition:

Carbon, min., per cent	0.45
Phosphorus, max., per cent	0.04

Ladle Analysis

6. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulfur. This analysis shall be made from drillings taken at least $\frac{1}{8}$ in. beneath the surface of a test ingot obtained during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and the percentages of carbon and phosphorus shall conform to the requirements specified in Section 5.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee A-1 on Steel.

These specifications are in effect a revision of and replace the former Standard Specifications for High-Carbon-Steel Splice Bars (A 5 – 14), which standard was accordingly discontinued in 1936.

Check Analysis

7. An analysis may be made by the purchaser from a finished joint bar representing each melt. The percentage of carbon thus determined shall conform to the requirement specified in Section 5, and the phosphorus content shall not exceed that specified by more than 25 per cent.

Tension Tests

8. The joint bars shall conform to the following minimum requirements as to tensile properties:

Tensile strength, min., lb. per sq. in.	85 000
Elongation in 2 in., min., per cent	15

Bend Tests

9. The bend test specimen specified in Section 11 shall stand being bent cold through 90 deg. around a pin the diameter of which is equal to three times the thickness of the specimen, without cracking on the outside of the bent portion.

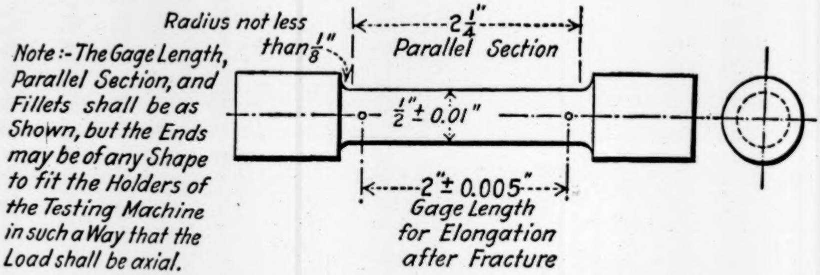
Radius not less than 1/8"
2 1/4"
Parallel Section
Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.
1/2" ± 0.01"
2" ± 0.005"
Gage Length for Elongation after Fracture

FIG. 1.—Standard 2-in. Gage Length Tension Test Specimen.

Optional Bend Test

10. If preferred by the manufacturer and approved by the purchaser, the following bend test may be substituted for that described in Section 9: A piece of the finished bar shall stand being bent cold through 45 deg. around a pin the diameter of which is equal to three times the greatest thickness of the section, without cracking on the outside of the bent portion.

Test Specimens

11. Tension and bend test specimens shall be taken from the finished joint bars. Tension test specimens shall conform to the dimensions shown in Fig. 1. Bend test specimens may be $\frac{1}{2}$ in. square in section or rectangular in section with two parallel faces as rolled and with corners rounded to a radius not over $\frac{1}{16}$ in.

Number of Tests

12. (*a*) One tension and one bend test shall be made from each melt.

(*b*) If any test specimen shows defective machining or develops flaws it may be discarded and another specimen substituted.

(*c*) If the percentage of elongation of any tension test specimen is less than that specified in Section 8 and any part of the fracture is more than $\frac{3}{4}$ in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

Workmanship

13. (*a*) The joint bars shall be smoothly rolled, true to template and shall accurately fit the rails for which they are intended. The bars shall be sheared to length, and the punching and slotting shall conform to the dimensions specified by the purchaser. A variation of $\pm \frac{1}{32}$ in. from specified size of holes, of $\pm \frac{1}{16}$ in. from specified location of holes and of $\pm \frac{1}{8}$ in. from specified length of joint bar will be permitted. Any variation from a straight line in a vertical plane shall be such as will make the bars high in the center. The maximum camber in either plane shall not exceed $\frac{1}{32}$ in. in 24-in. bars and $\frac{1}{16}$ in. in 36-in. bars.

Finish

14. The finished joint bars shall be free from injurious defects and shall have a workmanlike finish.

Marking

15. The name or brand of the manufacturer, the rail section weight and the year of manufacture shall be rolled in raised letters and figures on the side of the rolled bars, and a portion of this marking shall appear on each finished joint bar.

Inspection

16. The inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection

17. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 7 shall be reported within five working days from the receipt of samples.

(*b*) Joint bars which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing

18. Samples tested in accordance with Section 7, which represent rejected joint bars, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS

FOR

QUENCHED CARBON-STEEL JOINT BARS[1]

A.S.T.M. Designation: A 49 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Adopted, 1915; Revised, 1921; Reissued as Tentative, 1936.

Scope

1. These specifications cover heat-treated carbon-steel joint bars for general use in standard railroad tracks.

Process

2. The steel shall be made by either or both of the following processes: open-hearth or electric-furnace.

Discard

3. Sufficient discard shall be made from each ingot to insure freedom from piping and undue segregation.

Heating and Quenching

4. Joint bars shall be uniformly heated for punching, slotting and shaping and subsequently quenched.

Chemical Composition

5. The steel shall conform to the following requirements as to chemical composition:

Carbon, per cent	0.35 to 0.60
Manganese, max., per cent	0.80
Phosphorus, max., per cent	0.04

Ladle Analysis

6. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulfur. This analysis shall be made from drillings taken at least $\frac{1}{8}$ in. beneath the surface of a test ingot obtained during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and the percentages of carbon, manganese and phosphorus shall conform to the requirements specified in Section 5.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee A-1 on Steel.

These specifications are in effect a revision of and replace the former Standard Specifications for Quenched Carbon-Steel Joint Bars (A 49 – 21), which standard was accordingly discontinued in 1936.

Check Analysis

7. An analysis may be made by the purchaser from a finished joint bar representing each melt. The percentages of carbon and manganese thus determined shall conform to the requirements specified in Section 5, and the phosphorus content shall not exceed that specified by more than 25 per cent.

Tension Tests

8. (*a*) The joint bars shall conform to the following minimum requirements as to tensile properties:

Tensile strength, min., lb. per sq. in.	100 000
Yield point, min., lb. per sq. in.	70 000
Elongation in 2 in., min., per cent	12
Reduction of area, min., per cent	25

(*b*) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine operated at a cross-head speed not to exceed $\frac{1}{8}$ in. per min. The tensile strength shall be determined at a speed of head not to exceed $1\frac{1}{2}$ in. per min.

Bend Tests

9. The bend test specimen specified in Section 11 shall stand being bent cold through 90 deg. around a pin the diameter of which is equal to three times the thickness of the specimen, without cracking on the outside of the bent portion.

Optional Bend Test

10. If preferred by the manufacturer and approved by the purchaser, the following bend test may be substituted for that described in Section 9: A piece of the finished bar shall stand being bent cold through 45 deg. around a pin the diameter of which is equal to three times the greatest thickness of the section, without cracking on the outside of the bent portion.

Test Specimens

11. Tension and bend test specimens shall be taken from the middle of the head at the center of the finished joint bars. Tension test specimens shall conform to the dimensions shown in Fig. 1. Bend test specimens may be $\frac{1}{2}$ in. square in section or rectangular in section with two parallel faces as rolled and with corners rounded to a radius not over $\frac{1}{16}$ in.

Number of Tests

12. (*a*) One tension and one bend test shall be made from each melt.

(*b*) If any test specimen shows defective machining or develops flaws it may be discarded and another specimen substituted.

(*c*) If the percentage of elongation of any tension test specimen is less than that specified in Section 8 and any part of the fracture is more than $\frac{3}{4}$ in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

Retests

13. If the results of the physical tests of any test lot do not conform to the requirements specified, the manufacturer may retreat such test lot not more than twice, in which case two additional tension and two additional bend tests shall be made from such lot, all of which shall conform to the requirements specified.

Workmanship

14. The joint bars shall be smoothly rolled, true to template and shall accurately fit the rails for which they are intended. The bars shall be sheared to length, and the punching and slotting shall conform to the dimensions specified by the purchaser. A variation of $\pm\frac{1}{32}$ in. from specified size of holes, of $\pm\frac{1}{16}$ in. from specified location of holes and of $\pm\frac{1}{8}$ in. from specified length of joint bar will be permitted. Any variation from a straight line in a vertical plane shall be such as will make the bars high in the center. The maximum camber in either plane shall not exceed $\frac{1}{32}$ in. in 24-in. bars and $\frac{1}{16}$ in. in 36-in. bars.

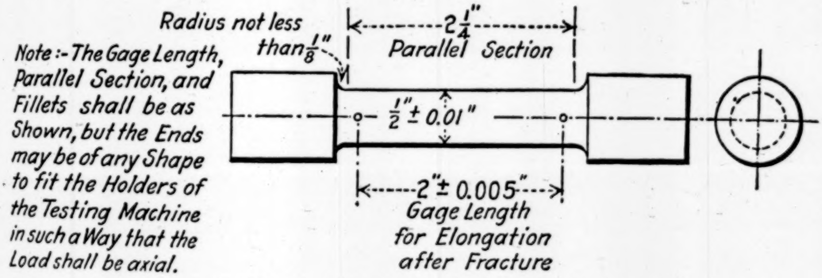
Radius not less than $\frac{1}{8}''$
$2\frac{1}{4}''$
Parallel Section
Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.
$\frac{1}{2}'' \pm 0.01''$
$2'' \pm 0.005''$
Gage Length for Elongation after Fracture

FIG. 1.—Standard 2-in. Gage Length Tension Test Specimen.

Finish

15. The finished joint bars shall be free from injurious defects and shall have a workmanlike finish.

Marking

16. The name or brand of the manufacturer, the rail section weight and the year of manufacture shall be rolled in raised letters and figures on the side of the rolled bars, and a portion of this marking shall appear on each finished joint bar.

Inspection

17. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of

the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection

18. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 7 shall be reported within five working days from the receipt of samples.

(*b*) Joint bars which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing

19. Samples tested in accordance with Section 7, which represent rejected joint bars, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS

FOR

HEAT-TREATED CARBON- AND ALLOY-STEEL TRACK BOLTS[1]

A.S.T.M. Designation: A 183 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1935; REVISED, 1936.

Scope

1. These specifications cover two grades of heat-treated carbon-steel and heat-treated alloy-steel track bolts.

Process

2. (*a*) The steel for the bolts shall be made by either or both of the following processes: open-hearth or electric-furnace.

(*b*) The steel for the nuts shall be made by one or more of the following processes: open-hearth, electric-furnace, or acid-bessemer.

Chemical Composition

3. (*a*) The steel for the bolts shall conform to the following requirements as to chemical composition:

	CARBON STEEL	ALLOY STEEL[a]
Carbon, min., per cent	0.30	....
Phosphorus, max., per cent	0.04	0.04
Sulfur, max., per cent	0.06	0.05

[a] The type of alloy to be used shall be mutually agreed upon by the manufacturer and purchaser.

(*b*) The steel for the nuts shall conform to the commercial quality of hot-rolled nut bar steel, and shall have a carbon range of from 0.15 to 0.25 per cent for open-hearth steel, 0.08 to 0.16 per cent for bessemer steel.

(*c*) When high strength nuts are specified, the steel shall conform to a carbon range of 0.40 to 0.55 per cent.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee A-1 on Steel.

These specifications are in effect a revision of, and replace the former Standard Specifications for Quenched Carbon-Steel Track Bolts (A.S.T.M. Designation: A 50 – 33) and Standard Specifications for Quenched Alloy-Steel Track Bolts (A.S.T.M. Designation: A 51 – 33), which standards were accordingly discontinued in 1936.

Ladle Analysis

4. (*a*) A carbon determination shall be made of each melt of bessemer steel, and determinations for manganese, phosphorus and sulfur representing the average of the melts applied for each 8-hr. period.

(*b*) An analysis of each melt of open-hearth or electric-furnace steel shall be made to determine the percentages of carbon, alloy when used, manganese, phosphorus and sulfur.

(*c*) The analyses prescribed in Paragraphs (*a*) and (*b*) shall be made by the manufacturer from test ingots taken during the pouring of each melt. The chemical composition thus determined shall be reported to the purchaser or his representative and shall conform to the requirements specified in Section 3.

Check Analysis

5. An analysis may be made by the purchaser from a finished bolt representing each melt. The phosphorus content thus determined shall not exceed that specified in Section 3 (*a*) by more than 25 per cent.

Tension Tests

6. (*a*) The finished bolts shall conform to the following minimum requirements as to tensile properties:

	Carbon Steel		
	Grade 1	Grade 2	Alloy Steel
Tensile strength, lb. per sq. in.	100 000	110 000	115 000
Yield point, lb. per sq. in.	70 000	80 000	85 000
Elongation in 2 in., per cent	12	14	15
Reduction of area, per cent	25	35	40

(*b*) The yield point shall be determined by the drop of the beam or halt in the gage ot the testing machine operated at a cross-head speed not to exceed $\frac{1}{8}$ in. per min. The tensile strength shall be determined at a speed of head not to exceed $1\frac{1}{2}$ in. per min.

Test Specimens

7. The tension test specimen taken from the finished bolt shall conform to the dimensions shown in Fig. 1.

Bend Tests

8. (*a*) Full-size carbon-steel bolts, Grades 1 and 2, shall stand being bent cold through 45 deg. around a pin, the diameter of which is equal to the diameter of the bolt, without cracking on the outside of the bent portion. If the bend test specimen breaks in the threaded portion, a retest shall be allowed.

(*b*) Full-size alloy-steel bolts shall stand being bent cold through 90 deg. around a pin, the diameter of which is equal to the diameter of the bolt, without cracking on the outside of the bent portion. If the bend test specimen breaks in the threaded portion, a retest shall be allowed.

Strip Test

9. The threads of the nut shall not "strip" when the bolt, with nut fully mounted, is tested in tension to its yield point, the load being applied to the head of the bolt and the bearing side of the nut.

Number of Tests

10. (*a*) One tension, one bend, and one strip test shall be made from each lot of 50 kegs or fraction thereof.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(*c*) If the percentage of elongation of any tension test specimen is less than that specified in Section 6 (*a*) and any part of the fracture is more than ¾ in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

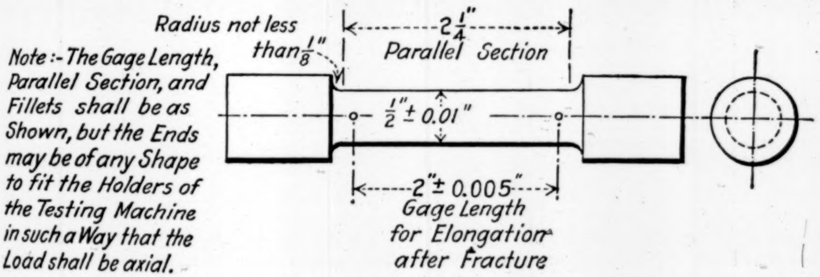
Radius not less than 1/8"
2 1/4"
Parallel Section
Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.
1/2" ± 0.01"
2" ± 0.005"
Gage Length for Elongation after Fracture

FIG. 1.—Standard 2-in. Gage Length Tension Test Specimen.

Retest

11. If the results of the physical tests of any test lot do not conform to the requirements specified, the manufacturer may retreat such lot not more than twice, in which case two additional tension, and two additional bend tests shall be made from such lot, all of which shall conform to the requirements specified.

Permissible Variations in Dimensions

12. (*a*) The bolts and nuts shall conform to the plans specified by the purchaser, subject to the following permissible variations:

		Permissible Variations, in.	
		Over	Under
Bolt	Shank diameter for cut-thread bolt	1/64	1/32
	Neck dimensions	1/32	1/32
	Length under head	1/8	1/8
	Height and diameter of head	1/16	1/16
Nut	Width	......	0.05 × thread diameter of bolt
	Height	(0.016 × thread diameter of bolt) +0.012	(0.016 × thread diameter of bolt) +0.012

(*b*) The outside diameter of the finished rolled threads shall not exceed the diameter of the shank of a cut thread bolt of corresponding size.

(*c*) The diameter of the rolled threads shall not exceed the diameter of the shank by more than $\frac{1}{16}$ in. for bolts $\frac{7}{8}$ in. in diameter and under, nor more than $\frac{3}{32}$ in. for bolts 1 in. in diameter and over.

Finish

13. The bolts and nuts shall be neatly formed and free from fins or nicks. The head of the bolt shall be concentric with and firmly joined to the shank, with the under side at right angles to the axis of the bolt. It shall be free from injurious defects and shall have a workmanlike finish.

Threads and Thread Fit

14. The threads on bolts may be rolled or cut and shall be of the American Standard shape as shown in the American Standard for Screw Threads, A.S.A. No.: B1.1–1935, or subsequent revisions thereof. The nut shall have a hand-free fit from two to five turns in starting on the bolt, shall be wrench tight the remainder of the screw length of the nut, and shall show a minimum resistance of 20 lb. and a maximum of 70 lb. applied to a 24-in. wrench when the nut is fully engaged. Before packing, nuts shall be screwed on the bolts for enough turns to hold them in place until used.

Marking

15. (*a*) A letter or brand indicating the manufacturer together with the numerals "1" and "2" for Grades 1 and 2, respectively, and the letter "A" for alloy-steel bolts, shall be pressed on the head of the bolt when it is formed.

(*b*) All containers shall be marked by the manufacturer as follows:

(*1*) Name of manufacturer.
(*2*) Material (Grade 1, Grade 2, or Alloy).
(*3*) Size of bolt (diameter and length).
(*4*) Weight.

Inspection

16. The inspector representing the purchaser shall have free entry at all times, while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the bolts and nuts ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to enable him to satisfy himself that the bolts and nuts are being furnished in accordance with these specifications. All tests (except check analysis) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection

17. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 5 shall be reported within five working days from the receipt of samples.

(*b*) Bolts and nuts which show injurious defects subsequent to their acceptance at the manufacturer's works shall be rejected and the manufacturer will be notified.

Rehearing

18. Samples tested in accordance with Section 5 which represent rejected bolts shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the test, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS
FOR
ONE-WEAR AND TWO-WEAR WROUGHT STEEL WHEELS[1]

A.S.T.M. Designation: A 186 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1936.

Scope

1. These specifications cover one-wear and two-wear wrought steel wheels commonly used for cars in freight and industrial service.

Process

2. The steel shall be made by either or both of the following processes: open-hearth or electric-furnace.

Discard

3. A sufficient discard shall be made from each ingot to secure freedom from piping and undue segregation.

Temperatures

4. During process of manufacture, necessary care in the regulation of temperature gradients shall be exercised to obtain the best physical properties expected from the chemical composition and mechanical work, and to prevent the development of faulty structure or injurious stresses in any part of the wheel.

Chemical Composition

5. The steel shall conform to the following requirements as to chemical composition:

Carbon, per cent	0.65 to 0.85
Manganese, per cent	0.60 to 0.85
Phosphorus, max., per cent	0.05
Sulfur, max., per cent	0.05
Silicon, min., per cent	0.15

Ladle Analyses

6. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements specified in Section 5. This

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee A-1 on Steel.

analysis shall be made from a test ingot taken during the pouring of each melt. The chemical composition thus determined, together with such identifying records as may be desired, shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 5.

Check Analyses

7. An analysis may be made by the purchaser from a wheel block or from a finished wheel selected from each melt by the inspector representing the purchaser. The chemical composition thus determined shall conform to the requirements specified in Section 5. Samples from wheel blocks shall be drilled from the end of the block at any point midway between the center and outside. The finished wheels may be sampled by taking drillings direct from the plate, or from a slug cored out of the plate; so taken as not to impair the usefulness of the wheel. Samples shall be taken by drilling entirely through the plate or slug. Drillings from any one block or wheel shall be thoroughly mixed together and they shall be clean and free from scale, oil and other foreign substances.

Mating

8. The wheels shall be mated as to one-half tape sizes and shipped in pairs.

Permissible Variations in Dimensions

9. The wheels shall conform to the dimensions specified within the following permissible variations:

Flange

(*a*) *Height of Flange.*—The height of flange shall not be less than 1 in. nor more than $1\frac{1}{8}$ in. Flanges unfilled more than $\frac{1}{32}$ in. shall not be permitted. No unfilled portion shall be permitted below the gaging point.

(*b*) *Thickness of Flange.*—The thickness of flange may vary. For one-wear wheels the variation shall not be more than $\frac{1}{32}$ in. over or $\frac{3}{32}$ in. under that specified. For two-wear wheels the variation shall not be more than $\frac{1}{16}$ in. over or $\frac{1}{16}$ in. under that specified.

(*c*) *Radius of Throat.*—The radius of throat shall not vary more than $\frac{1}{16}$ in. from that specified.

Rim

(*d*) *Tape Sizes.*—The tape sizes of the wheels shall not be less than that specified, and shall not exceed this by more than 14 tapes, except 5 per cent of any order may vary 5 tapes under size specified, provided the average tape sizes on any one order shall not be less than standard size.

(*e*) *Thickness of Rim.*—The thickness of rim shall be measured radially of the wheel on the back face of the rim with a standard A.A.R. steel wheel

TABLE I.—PERMISSIBLE VARIATIONS IN DIMENSIONS OF ONE-WEAR AND TWO-WEAR WROUGHT STEEL WHEELS.

Dimensions	Dimensional Limits, in.	Permissible Variations in Dimensional Limits, in.	
		Over	Under
FLANGE			
(*a*) Height of flange	1 min. $1\frac{1}{8}$ max.	....	....
(*b*) Thickness of flange:			
1. One-wear wheels	....	$\frac{1}{32}$	$\frac{3}{32}$
2. Two-wear wheels	....	$\frac{1}{16}$	$\frac{1}{16}$
(*c*) Radius of throat	....	$\frac{1}{16}$	$\frac{1}{16}$
RIM			
(*d*) Tape sizes	....	14 tapes	0
1. On any order 5 per cent may vary 5 tapes under size specified provided average tape sizes are not less than standard size.			
(*e*) Thickness of rim:			
1. Thickness, at back face of wheel:			
One-wear wheels	$1\frac{1}{4}$	....	....
Two-wear wheels	2	....	....
2. Maximum variation in rim thickness measured 1 in. from front face of wheel	$\frac{1}{8}$	....	....
3. Variations of 5 per cent of wheels in any one order	....	....	$\frac{1}{8}$
4. Variations of rim thickness on any two radii in any one wheel	$\frac{1}{8}$	....	....
5. Radius of inside edge of back face of rim	$\frac{1}{8}$ max.	....	....
(*f*) Maximum variation in rim thickness measured 1 in. from front face of wheel	$\frac{1}{8}$	....	....
(*g*) Inside diameter of rim at back face of wheel	....	....	$\frac{3}{8}$
(*h*) Inside diameter of rim at front face of wheel in relation to inside diameter at back face of wheel	....	$\frac{1}{4}$	$\frac{1}{4}$
(*i*) Width of rim	....	$\frac{1}{8}$	$\frac{1}{8}$
(*j*) Maximum departure of any point on back face from plane of rim	$\frac{1}{16}$	....	....
(*k*) Maximum departure of tread from rotundity	$\frac{1}{32}$	....	....
(*l*) Maximum height of block marks on tread	$\frac{1}{64}$	....	....
PLATE			
(*m*) Thickness of plate	not less than dimensions shown on drawings.		
HUB			
(*n*) Diameter of hub:			
1. Minimum thickness of finished bored hub wall — Nominal bores 7 in. or under	1	....	....
1. Minimum thickness of finished bored hub wall — Nominal bores over 7 in.	$1\frac{1}{4}$	....	....
2. Maximum variation in thickness of wall in any one wheel	$\frac{3}{8}$	....	....
(*o*) Length of hub	....	$\frac{1}{4}$	$\frac{1}{4}$
(*p*) Depression below front face of rim	....	$\frac{1}{4}$	0
(*q*) Projection beyond back face of rim of hub	not to exceed maximum dimensions shown on drawings.		
BORE			
(*r*) Diameter of bore	....	$\frac{1}{16}$	$\frac{1}{8}$
1. When not specified, rough bore shall be $\frac{1}{4}$ in. less in diameter than finished bore			
(*t*) Maximum eccentricity of rough bore in relation to tread	$\frac{3}{64}$	....	....

NOTE.—The letter used for each dimension in this table and in Fig. 1 is the same as that of the paragraph of Section 9 covering that dimension.

gage, or an approved equivalent. The thickness of rim thus measured shall not be less than 1¼ in. for one-wear wheels or 2 in. for two-wear wheels, except that 5 per cent of the wheels in any one order may vary as much as ⅛ in. under the specified dimension. The rim thickness shall not vary more than ⅛ in. on any two radii in any one wheel. To facilitate measurements of rim thickness, the radius of the inside edge of the back face of the rim shall not exceed ⅛ in. A sharp corner is preferable.

(*f*) *Front Rim Thickness.*—The rim thickness, measured radially on a plane 1 in. from the front face of the wheel, shall not vary more than ⅛ in. in any one wheel. The contour of the inner surface of the rim shall be practically symmetrical on both sides of the plate.

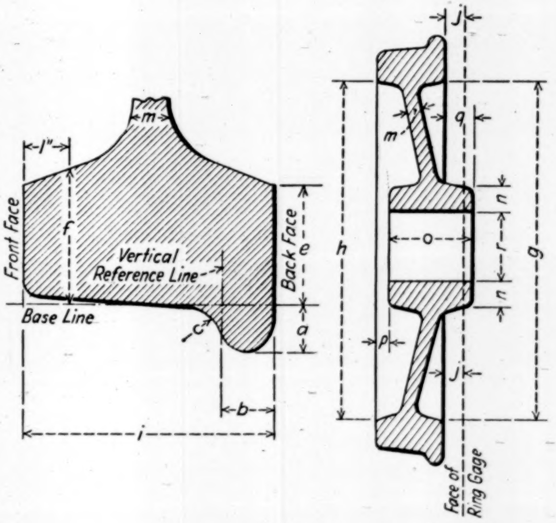

FIG. 1.—Diagram Showing Points at which the Dimensions Covered by Specifications are Measured.

For the Permissible Variations in these Dimensions, see Table I or Section 8.
The letter used for each dimension in this figure and in Table I is the same as that of the paragraph of Section 9 on Permissible Variations in Dimensions covering that dimension.

(*g*) *Inside Diameter* (*Back Face of Rim*).—The inside diameter of the rim at the back face of the wheel shall not vary more than ⅜ in. under that specified.

(*h*) *Inside Diameter* (*Front Face of Rim*).—The inside diameter of the rim at the front face of the wheel and the inside diameter at the back face shall not vary more than ¼ in.

(*i*) *Width of Rim.*—The width of rim shall not vary more than ⅛ in. from that specified.

(*j*) *Plane of Back Face.*—The wheels shall be gaged with a straight edge, applied to the back face of the rim. No point on the back face shall be more than $\frac{1}{16}$ in. from the straight edge when so applied.

(*k*) *Rotundity.*—The tread shall be gaged with a ring gage, and the opening between the tread and this gage at any point shall not exceed $\frac{1}{32}$ in.

(*l*) *Block Marks on Tread.*—Block marks shall not exceed $\frac{1}{64}$ in. in height.

Plate

(*m*) *Thickness of Plate.*—The thickness of the plate may vary, but shall not be less than that shown on the drawings.

Hub

(*n*) *Diameter of Hub.*—The diameter of hub may vary but the thickness of the wall of finished bored hub shall not be less than 1 in. at any point for all nominal bores 7 in. or under, nor less than 1$\frac{1}{4}$ in. for all nominal bores over 7 in. The thickness of the hub wall in any wheel shall not vary more than $\frac{3}{8}$ in. at any two points equidistant from the face of the hub.

(*o*) *Length of Hub.*—The length of hub shall not vary more than $\frac{1}{4}$ in. from that specified.

(*p*) *Depression of Hub.*—The depression of the hub below the front face of the rim shall not be less, but may be $\frac{1}{4}$ in. more, than that specified, based on specified rim width.

(*q*) *Projection of Hub.*—Projection of hub beyond the back face of the rim shall not exceed the maximum dimension shown on drawings.

Bore

(*r*) *Diameter of Bore.*—The diameter of bore shall not vary more than $\frac{1}{16}$ in. over, nor $\frac{1}{8}$ in. under that specified. When not specified, the rough bore shall be $\frac{1}{4}$ in. less in diameter than the finished bore, subject to the above limitations.

(*s*) *Black Spots in Bore.*—No wheels shall have black spots in the rough bore which will not be completely removed in finish boring.

(*t*) *Eccentricity of Bore.*—The eccentricity between the rough bore and the tread shall not exceed $\frac{3}{64}$ in.

Finish

10. (*a*) Wheels shall be rough bored; faces of hub may be furnished as forged, and contour of tread and flange as rolled.

(*b*) The wheels shall have a workmanlike finish. They shall be free from defects liable to develop in and cause removal from service.

(*c*) Wheels shall not be offered for inspection if covered with paint, rust, or any other substance to such an extent as to hide defects.

Markings

11. (*a*) The date (month and year), brand of manufacturer, manufacturer's serial number, heat number, and identification mark 1-W for one-wear wheels or 2-W for two-wear wheels shall be legibly stamped on the back face of the rim. The height of the characters shall not be less than $\frac{5}{8}$ in. for hot stamping, nor $\frac{1}{2}$ in. for cold stamping.

(*b*) The tape size shall be plainly stenciled on the back plate in figures at least 1 in. in height.

Inspection

12. (*a*) The gages and tapes used shall be based on standards of the Association of American Railroads.

(*b*) The inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the wheels ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the wheels are being furnished in accordance with these specifications. All tests (except check analysis) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

(*c*) The purchaser may make the tests to govern the acceptance or rejection of wheels in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

Rejection

13. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 12 (*c*) shall be reported within five working days from the receipt of samples.

(*b*) Wheels which show injurious defects while being finished by the purchaser will be rejected, and the manufacturer shall be notified.

Rehearing

14. Samples tested in accordance with Section 12 (*c*), which represent rejected wheels, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS

FOR

CARBON-STEEL CASTINGS FOR MISCELLANEOUS INDUSTRIAL USES[1]

A.S.T.M. Designation: A 27 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Adopted, 1901; Revised, 1905, 1912, 1913, 1914, 1916, 1921, 1924;
Reissued as Tentative, 1936.

Scope

1. These specifications cover carbon-steel castings to be used for miscellaneous industrial purposes, as distinguished from carbon-steel castings made for railroad and high-temperature applications. Ten grades[2] of castings are covered: namely,

Grade N-1.—Castings of this grade as specified by the purchaser, not required to be physically tested, nor to be heat-treated in any manner except as conditionally provided for in Sections 3 and 13 (*b*).

Grade N-2.—Castings of this grade as specified by the purchaser, not required to be physically tested, but required to be annealed.

Grade A-1.—Castings of this grade as specified by the purchaser, required to be physically tested, but not required to be heat-treated except as conditionally provided for in Section 3.

Grade A-2.—Castings of this grade as specified by the purchaser, required to be annealed and to be physically tested.

Grade A-3.—Castings of this grade as specified by the purchaser, required to be full annealed and to be physically tested.

Grade B.—Castings of this grade as specified by the purchaser, required to be annealed and to be physically tested.

Grade B-1.—Castings of this grade as specified by the purchaser, required to be full annealed and to be physically tested.

Grade B-2.—Castings of this grade as specified by the purchaser, required to be full annealed and to be physically tested.

Grade H.—Castings of this grade as specified by the purchaser, required to be annealed and to be physically tested.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee A-1 on Steel.

[2] **See Explanatory Notes.**

Grade H-1.—Castings of this grade as specified by the purchaser, required to be full annealed and to be physically tested.

Process

2. The steel shall be made by one or more of the following processes: open-hearth, electric-furnace, converter, or crucible.

Heat Treatment

3. (*a*) A heat treatment, either by normalizing or by full annealing at the option of the manufacturer, shall be applied to all castings of Grades N-2, A-2, B, and H; also to all castings of Grades N-1 and A-1 when their carbon content exceeds 0.30 per cent (Note 1). A full annealing treatment shall be applied to all castings of Grades A-3, B-1, B-2, and H-1. Unless otherwise specified, all castings may be annealed one or more times, and may be given a supplementary heat treatment by tempering or drawing. When mutually agreed upon by the purchaser and manufacturer, castings specifically designated in any grade except Grades A-1, A-3, B-1, B-2, and H-1 may be given a supplementary heat treatment that includes accelerated cooling by liquid quenching, liquid spraying, or air blasting (Note 2).

(*b*) All those castings that are to be heat treated in any manner shall have been allowed to cool after pouring, to a temperature below the critical range.

(*c*) *Normalizing.*—The procedure for normalizing shall consist of heating the castings to the proper temperature above the critical range for the required time as a preliminary procedure for the ultimate refinement of the grain, and cooling in still air at room temperature (Note 3).

(*d*) *Full Annealing.*—The procedure for full annealing shall consist of heating the castings to the proper temperature above the critical range for the required time as a preliminary procedure for the ultimate refinement of the grain, and cooling slowly in the furnace (Note 3). No casting so treated shall be removed from the furnace until the pyrometer indicates that the entire furnace charge has fallen to a temperature of 500 F. (260 C.), or lower.

(*e*) *Tempering or Drawing.*—The procedure for tempering or drawing shall consist of heating such castings as have been normalized or full annealed, or have been given an authorized accelerated cooling, to a temperature below the critical range but not less than 400 F. (204 C.), and cooling by a suitable method to obtain the desired results.

(*f*) *Cooling.*—The procedure for accelerated cooling by liquid quenching, liquid spraying, or air blasting shall follow heating the castings gradually to a suitable temperature (above or below the critical range), and holding at that temperature for the proper time to obtain the desired results. All castings that have been cooled by liquid contact or by an air blast shall be tempered or drawn to relieve cooling stresses or strains, or both, unless otherwise agreed to by the purchaser. With the exception of castings of very simple light-section design, all liquid-quenched material shall be removed from the quenching bath before the castings attain room temperature, and shall be placed in the heat treatment furnace for any required tempering or drawing immediately following removal from the quenching bath (Note 4).

NOTE 1.—According to current, officially accepted definitions, the term "heat treatment" covers any method of intentionally and systematically applying heat at a temperature below the melting point, to a metal after it has cooled following pouring. Consequently the term now is used without regard to whether such heat is applied one or more times, and irrespective of the cooling procedure. The term "annealing" is authoritatively intended to cover either "normalizing" (air cooling) or "full annealing" (furnace cooling).

NOTE 2.—Accelerated cooling by liquid contact develops properties that are advantageous for certain purposes, when the details of steel casting design, of chemical composition, and of shop practice are suitable for liquid quenching or liquid spraying. The beneficial results obtainable by liquid quenching or liquid spraying include differential hardening, whereby some surfaces are made noticeably resistant to abrasion, while other portions of the castings retain more ductile and more easily machinable properties.

NOTE 3.—The proper time for holding or "soaking" many castings of moderate thickness at maximum temperature in the heat treating furnace is believed by many persons to be one hour per inch of thickness of the heaviest member.

NOTE 4.—Usually, the absence or degree of hazard resulting from cooling by liquid contact is estimated somewhat in proportion to the similarity or extent, or both, of member-thickness.

Temperature Control

4. Furnace temperatures for heat treating shall be controlled effectively by pyrometers.

Chemical Composition

5. Steel used for the castings shall conform to the following requirements as to chemical composition:

Manganese, max., per cent	1.00
Phosphorus, max., per cent	0.05
Sulfur, max., per cent	0.06

Ladle Analysis

6. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, silicon, phosphorus, and sulfur. This analysis shall be made from drillings taken at least ¼ in. beneath the surface of a test ingot made during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and the percentages of manganese, phosphorus and sulfur shall conform to the requirements specified in Section 5.

Check Analysis

7. An analysis may be made by the purchaser from a broken tension test specimen or from a casting representing any melt. The chemical

composition thus determined shall conform to the requirements specified in Section 5. Drillings for analysis shall be taken at least $\frac{1}{4}$ in. beneath the surface, and in such manner as not to impair the usefulness of any casting selected for such check analysis.

Tension Tests

8. (*a*) The tensile properties[1] of steel used for castings of the grades that require physical testing shall be determined from the required number of specimens having a 2-in. gage length, conforming to the dimensions shown in Fig. 1.

(*b*) One or more test coupons sufficient in size and number to provide the required test specimens shall be cast separately or attached to one or more castings of the kind ordered by the purchaser, in each melt used for manufacture of the purchased material (Note 5). Unless otherwise specified or agreed to between the purchaser and manufacturer, the test coupons shall be designed by the manufacturer and may be cast separately (Note 6).

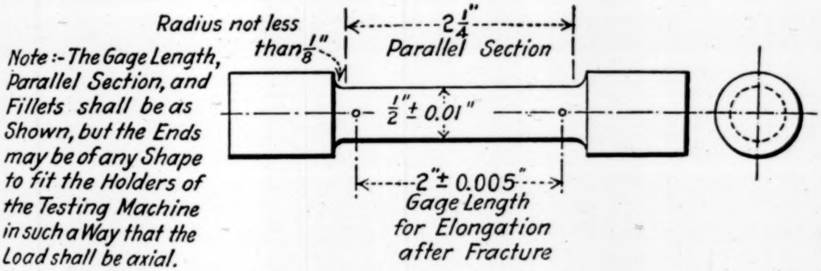
Radius not less than 1/8"
2 1/4"
Parallel Section
Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.
1/2" ± 0.01"
2" ± 0.005"
Gage Length for Elongation after Fracture

FIG. 1.—Standard 2-in. Gage Length Tension Test Specimen.

NOTE 5.—The direct attachment of test coupons for their entire length and width to commercial castings of certain designs is inadvisable, even when the castings are sufficiently large to permit such attachment. A test coupon may be so formed and attached as to "bleed" the connected casting, thereby forming a solid coupon while injuring a member which may function largely as a feeding head for the coupon. The attachment of test coupons to commercial castings by means of runners is not open to the objection cited.

NOTE 6.—The special test block conventionally used in many steel foundries, frequently called a "keel-block," consists of a slab or plate having a small area and one or more underlying ribs. The slab or upper portion is made sufficiently thick to properly feed the ribs or coupons, which often are approximately 1 in. in thickness. Specimens from coupons made uniformly in some such manner afford reliable means for making accurate comparative evaluations of steel used for casting manufacture.

Higher combinations of physical properties than those specified herein are obtained in testing specimens from coupons on conventional test blocks, when the coupons are liquid quenched and subsequently tempered or drawn.

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[1] **Because it has come to the attention of Committee A-1 on Steel that the intent of tension test requirements in some specifications has at times been misinterpreted, the committee wishes to make it clear that it is not intended that a maximum limit shall be placed on any tensile property required in these specifications.**

(*c*) Steel used for the castings shall conform to the following minimum requirements as to tensile properties:

	TENSILE STRENGTH, MIN., LB. PER SQ. IN.	YIELD POINT, MIN., LB. PER SQ. IN.	ELONGATION IN 2 IN., MIN., PER CENT	REDUCTION OF AREA, MIN., PER CENT
Grade A-1, Unannealed	60 000	30 000	22	30
Grade A-2, Normalized[a]	60 000	30 000	26	38
Grade A-3, Full annealed	60 000	30 000	24	35
Grade B, Normalized[a]	70 000	38 000	24	36
Grade B-1, Full annealed	66 000	33 000	22	33
Grade B-2, Full annealed	70 000	35 000	20	30
Grade H, Normalized[a]	80 000	43 000	17	25
Grade H-1, Full annealed	80 000	40 000	17	25

[a] Any casting that may be ordered to meet the tensile requirements above listed for normalized material of Grades A-2, B, and H may, at the option of the manufacturer, be given a full annealing treatment instead of a normalizing treatment; provided that the above listed tensile requirements for normalized material are met.

(*d*) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine, or by an extensometer, at a crosshead speed not to exceed $\frac{1}{8}$ in. per min. The tensile strength shall be determined at a speed of head not to exceed $1\frac{1}{2}$ in. per min.

Test Specimens

9. (*a*) Such physical test coupons as may have been connected directly or by runners to commercial castings (Section 8 (*b*)) shall remain so attached until the material is submitted for inspection. All physical test coupons shall be heat treated with the castings represented by them unless the purchaser authorizes separate heat treatment. Test coupons shall be provided by the manufacturer without extra charge in sufficient number to furnish specimens for all tests, except as otherwise agreed to between the purchaser and manufacturer.

(*b*) If agreed to between the manufacturer and the purchaser's inspector, tension test specimens may be taken from commercial castings instead of from special coupons.

(*c*) Tension test specimens shall be machined by the manufacturer and shall conform to the dimensions shown in Fig. 1. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

Number of Tests

10. (*a*) One tension test shall be made from each melt in each heat treatment charge.

(*b*) If any test specimen shows defective machining or develops flaws it may be discarded, in which case another specimen from the same lot[1] shall be substituted.

(*c*) After the acceptance (for one or more orders) of 15 consecutive melts containing castings subject to physical tests, the manufacturer may assemble the castings from succeeding melts in groups of five melts each, not exceeding 40 tons in weight per group. Each such group shall be accepted if the chemical analyses and the specimen representing the group fulfill the chemical and physical requirements of these specifications. If this test fails, a rehearing shall be granted for the melt represented by the failed specimen, and the four other melts of the group shall be tested individually.

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[1] The term "lot" as used in this paragraph means all castings from each melt in each heat-treatment charge.

Retests

11. (*a*) If the results of the physical test for any lot[1] do not conform to the requirements specified, the manufacturer may reheat-treat such lot, but not more than twice. The results of acceptable retests shall conform to the requirements specified in Section 8 (*c*).

(*b*) If the percentage of elongation of any tension test specimen is less than that specified in Section 8 and any part of the fracture is more than $\frac{3}{4}$ in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

Workmanship

12. All castings shall be made in a workmanlike manner and shall conform substantially to the dimensions on drawings furnished by the purchaser before manufacture is started; or to the dimensions predicated by the pattern supplied by the purchaser, if no drawing has been provided.

Finish

13. (*a*) The castings shall be free from injurious defects, and shall be satisfactorily cleaned for their intended use when offered for inspection.

(*b*) Minor defects that will not ultimately impair the strength of the castings may, with the consent of the purchaser's inspector, be welded by an approved process. The defects shall first be cleaned out to solid metal, and after the castings are welded they shall be heat treated, if required by the purchaser's inspector.

Marking

14. The manufacturer's name or identification mark and the pattern number, also the purchaser's identification marks when specified, shall be cast on all castings excepting those of such small size as to make such marking impracticable. In addition, the numbers of the melts used for pouring the castings shall be stamped on all castings individually weighing 300 lb. or more. The locations and sizes of cast identification marks shall be as agreed upon between the manufacturer and the purchaser's inspector (Note 7).

NOTE 7.—The resistance of a sand mold to the erosive effect of in-flowing metal is aided by smooth mold surfaces. Cast identification marks are formed by making indentations on the face of the mold. For the prevention of small defects caused by dislodged particles of molding sand there should be provided the minimum feasible number of cast identification marks.

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[1] The term "lot" as used in this paragraph means all castings from each melt in each heat-treatment charge.

Inspection

15. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection

16. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with these specifications shall be reported within five working days from the receipt of samples.

(*b*) Material which shows injurious defects following original inspection and acceptance at the manufacturer's works shall be rejected. The manufacturer shall be notified promptly of such rejection.

Rehearing

17. Tested samples representing rejected material shall be held for 14 days from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

EXPLANATORY NOTES

NOTES REGARDING SELECTION AND CHARACTERISTICS OF GRADES

Grades A-1, A-2 and A-3 are produced intentionally with such low carbon contents as to make the material very soft and machineable with great ease, either in the "as-cast," normalized, or full-annealed condition. The carbon contents commonly found in these grades effectively adapt them for fusion fabrication with such wrought parts as often are made of low carbon-steel.

Grade B (normalized) is used in making a great many carbon-steel castings purchased for miscellaneous industrial applications. Grade B-1 (full annealed) and Grade B-2 (full annealed) are used often for castings whose intended use or member-thickness, or both, cause the purchasers or manufacturers to prefer a full annealing treatment for the development of desired physical properties and for the prevention of any stresses that might be induced by the cooling operation that is incidental to normalizing. Grade B-1, characterized by tensile requirements slightly different from those specified for Grade B-2, is used in preference to the latter by many bridge engineers. Grades B, B-1, and B-2 are easily machined with ordinary machine tools.

Grade H (normalized) and Grade H-1 (full annealed) are used for purposes that call for higher strength and less ductility than are typical of the other grades, and usually are machined without appreciable difficulty by means of modern machine tools.

The tensile requirements for the full annealed grades that are specified herein can be met by specimens made from test coupons of customary proportions, cast separately or attached in any manner to commercial castings of any size, after a full annealing treatment of proper time cycle for the material purchased.

TENTATIVE SPECIFICATIONS

FOR

SEAMLESS STEEL BOILER TUBES FOR HIGH-PRESSURE SERVICE[1]

A.S.T.M. Designation: A 192 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1936.[2]

Scope

1. These specifications cover seamless steel boiler tubes and superheater tubes 2 in. in outside diameter or larger and heavier than 0.203-in. minimum wall thickness.

Process

2. The steel shall be a killed steel and shall be made by either or both of the following processes: open-hearth or electric-furnace.

Manufacture

3. (*a*) Tubes shall be made by the seamless process and shall be either hot finished or cold drawn, as specified.

(*b*) Cold-drawn tubes shall be annealed "dead soft" after the final cold-draw pass. Hot-finished tubes need not be annealed unless specified by the purchaser.

Chemical Composition

4. The steel shall conform to the following requirements as to chemical composition:

Carbon, per cent	0.08 to 0.18
Manganese, per cent	0.30 to 0.60
Phosphorus, max., per cent	0.04
Sulfur, max., per cent	0.045
Silicon, max., per cent	0.25

Check Analyses

5. (*a*) Analyses of two tubes in each lot of 100 lengths or fraction thereof may be made by the purchaser. Drillings for analysis shall be taken from several points around each tube selected for analysis.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee A-1 on Steel.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 26, 1936.

(*b*) If the analysis of either tube does not conform to the requirements specified, analyses of two additional tubes from the same lot shall be made, each of which shall conform to the requirements specified.

Flattening Tests

6. A section of tube 2½ in. in length shall stand being flattened between parallel plates, without cracking or showing any flaw, until the distance between the plates is four times the wall thickness.

Flaring Test

7. A section of the tube approximately 4 in. in length shall stand being flared with a tool having a 60-deg. included angle until the tube at the mouth of the flare has been expanded to the following percentages, without cracking or showing flaws:

RATIO OF INSIDE DIAMETER TO OUTSIDE DIAMETER[a]	MINIMUM EXPANSION OF INSIDE DIAMETER, PER CENT
0.9	20
0.8	22
0.7	25
0.6	30
0.5	37
0.4	50
0.3	67

[a] In determining the ratio of inside diameter to outside diameter, the inside diameter shall be defined as the actual inside diameter of the material tested.

Hardness Test

8. (*a*) A Brinell test shall show a hardness number not to exceed the following:

	BRINELL HARDNESS NUMBER
Hot-finished tubes	137
Cold-drawn tubes	125

(*b*) The hardness test may be made on the tube near the end or on a specimen cut from the tube, at the option of the manufacturer.

(*c*) In making the Brinell hardness test, reference should be made to the Standard Methods of Brinell Hardness Testing of Metallic Materials (A.S.T.M. Designation: E 10) of the American Society for Testing Materials.[1] In the case of tubes with wall thicknesses less than ⅜ in., a 10-mm. ball with 1500-kg. load, or a 5-mm. ball with 750-kg. load, may be used, at the option of manufacturer.

(*d*) *Alternate.*—The Rockwell hardness test may be used instead of the Brinell test, when desirable, in which case the test shall show a hardness number not to exceed the following:

	ROCKWELL HARDNESS NUMBER
Hot-finished tubes	B77
Cold-drawn tubes	B72

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[1] 1936 Book of A.S.T.M. Standards, Part I, p. 817.

(*e*) In making the Rockwell hardness test, reference should be made to the Standard Methods of Rockwell Hardness Testing of Metallic Materials (A.S.T.M. Designation: E 18) of the American Society for Testing Materials.[1]

Hydrostatic Test

9. Each tube shall be tested at the mill to a hydrostatic pressure of 2500 lb. per sq. in., prior to upsetting, swaging, expanding, or other forming operations, provided that the fiber stress, according to the following formula, does not exceed 16,000 lb. per sq. in.:

$$P = \frac{2\,St}{D}$$

where P = the hydrostatic test pressure in pounds per square inch,
S = the allowable fiber stress of 16,000 lb. per sq. in.,
t = the thickness of tube wall in inches, and
D = the outside diameter of tube in inches.

Test Specimens

10. (*a*) Test specimens required for the flattening and flaring tests under Sections 6 and 7 shall be taken from the ends of finished tubes prior to upsetting, swaging, expanding or other forming operations, or being cut to length. They shall be smooth on the ends and free from burrs and flaws.

(*b*) All specimens shall be tested at room temperature.

Number of Tests

11. (*a*) From each lot of 100 tubes, or fraction thereof, four tubes shall be selected for test. From each end of two of these test tubes, the flattening test specified in Section 6 shall be made and from each end of the other two test tubes the flaring test specified in Section 7 shall be made.

(*b*) Five per cent of all tubes shall be selected for the hardness test, specified in Section8 and one Brinell determination shall be made on each of these tubes.

(*c*) Each tube shall be subjected to the hydrostatic test, specified in Section 9.

Retests

12. If the results of any physical tests of any lot do not conform to the requirements specified in Sections 6, 7 and 8, retests may be made on additional tubes of double the original number from the same lot, each of which shall conform to the requirements specified.

Forming Operations

13. Tubes when inserted in the boiler shall stand expanding and bead-

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[1] 1936 Book of A.S.T.M. Standards, Part I, p. 824.

ing without showing cracks or flaws. Superheater tubes when properly manipulated shall stand all forging, welding and bending operations necessary for application without developing defects.

Standard Weights

14. The standard weights for tubes of various outside diameters and thicknesses are given in Table I.

TABLE I.—STANDARD WEIGHTS OF SEAMLESS BOILER TUBES AND SUPERHEATER TUBES.

Wall Thickness, Equivalent Decimal, in.	Weight, lb. per ft. of Length								
	Size, Outside Diameter, in.								
	2 (2.000)	$2\frac{1}{4}$ (2.250)	$2\frac{1}{2}$ (2.500)	$2\frac{3}{4}$ (2.750)	3 (3.000)	$3\frac{1}{4}$ (3.250)	$3\frac{1}{2}$ (3.500)	$3\frac{3}{4}$ (3.750)	4 (4.000)
0.220	4.182	4.770	5.357	5.944	6.532	7.119	7.707	8.294	8.881
0.240	4.511	5.152	5.793	6.434	7.074	7.715	8.356	8.997	9.638
0.260	4.832	5.526	6.220	6.914	7.608	8.303	8.997	9.691	10.385
0.280	5.143	5.891	6.639	7.386	8.134	8.881	9.629	10.377	11.124
0.300	5.447	6.248	7.049	7.850	8.651	9.452	10.253	11.054	11.855
0.320	5.742	6.596	7.450	8.305	9.159	10.013	10.868	11.722	12.577
0.340	6.028	6.936	7.843	8.751	9.659	10.567	11.475	12.382	13.290
0.360	6.305	7.267	8.228	9.189	10.150	11.111	12.073	13.034	13.995
0.380	6.575	7.589	8.604	9.618	10.633	11.648	12.662	13.677	14.691
0.400	6.835	7.903	8.971	10.039	11.107	12.175	13.243	14.311	15.379
0.420	7.087	8.209	9.330	10.451	11.573	12.694	13.816	14.937	16.058
0.440	7.331	8.506	9.680	10.855	12.030	13.205	14.380	15.554	16.729
0.460	7.566	8.794	10.022	11.250	12.479	13.707	14.935	16.163	17.391
0.480	7.792	9.074	10.355	11.637	12.919	14.200	15.482	16.763	18.045
0.500	8.010	9.345	10.680	12.015	13.350	14.685	16.020	17.355	18.690
	$4\frac{1}{2}$ (4.500)	5 (5.000)	$5\frac{1}{4}$ (5.250)	$5\frac{3}{8}$ (5.375)	$5\frac{1}{2}$ (5.500)	6 (6.000)	$6\frac{1}{4}$ (6.250)	$6\frac{1}{2}$ (6.500)	7 (7.000)
0.220	10.056	11.231	11.818	12.112	12.406	13.581	14.168	14.755	15.930
0.240	10.919	12.201	12.842	13.162	13.482	14.764	15.405	16.046	17.327
0.260	11.774	13.162	13.856	14.203	14.550	15.939	16.633	17.327	18.716
0.280	12.619	14.115	14.862	15.236	15.610	17.105	17.853	18.600	20.095
0.300	13.457	15.059	15.860	16.260	16.661	18.263	19.064	19.865	21.467
0.320	14.286	15.994	16.849	17.276	17.703	19.412	20.266	21.121	22.830
0.340	15.106	16.921	17.829	18.283	18.737	20.553	21.460	22.368	24.184
0.360	15.917	17.840	18.801	19.282	19.762	21.685	22.646	23.607	25.529
0.380	16.721	18.750	19.764	20.272	20.779	22.808	23.823	24.837	26.867
0.400	17.515	19.651	20.719	21.253	21.787	23.923	24.991	26.059	28.195
0.420	18.301	20.544	21.665	22.226	22.787	25.030	26.151	27.272	29.515
0.440	19.079	21.428	22.603	23.191	23.778	26.128	27.302	28.477	30.827
0.460	19.848	22.304	23.532	24.146	24.761	27.217	28.445	29.673	32.150
0.480	20.609	23.171	24.453	25.094	25.755	28.298	29.579	30.861	33.424
0.500	21.360	24.030	25.365	26.033	26.700	29.370	30.706	32.040	34.710

NOTE.—The weights given in the above table are theoretical and are based on tubes having a perfect outside diameter, inside diameter and wall thickness. Minimum wall tubes, as called for in these specifications, will weigh from 10 to 15 per cent heavier than those shown, depending on the size and wall thickness specified.

Permissible Variations in Dimensions and Weight

15. Variations in outside diameter, wall thickness, weight and length, from those specified, shall not exceed the amounts shown in Table II.

Finish

16. Finished tubes shall be reasonably straight and have smooth ends, free from burrs. They shall be free from injurious defects and have a

workmanlike finish. Minor defects may be removed by grinding provided the wall thicknesses and the outside diameter are not decreased to less than that permitted in Section 15.

Marking

17. The name or brand of the manufacturer, the words Seamless Steel, A.S.T.M. Specification A 192 – 36 T, together with the hydrostatic pressure in pounds at which it was tested and whether hot-finished or cold-drawn, shall be legibly stenciled on each tube.

Inspection

18. (*a*) Unless otherwise specified, inspection and all tests shall be made at the place of manufacture. When required, the manufacturer shall furnish the purchaser of each lot of tubes a statement as to the kind of material of which the tubes are made and that the tubes have been tested and have met all requirements of these specifications.

TABLE II.—PERMISSIBLE VARIATIONS IN DIMENSIONS AND WEIGHT OF SEAMLESS BOILER AND SUPERHEATER TUBES.

Size, Outside Diameter	Outside Diameter, in.[a], [b]		Wall Thickness,[c] per cent				Weight per Foot, per cent				Length, in.[d]	
			Cold Drawn		Hot Finished		Cold Drawn		Hot Finished			
	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under
4 in. and under.......	$\frac{1}{64}$	$\frac{1}{32}$	22	0	28	0	15	0	$17\frac{1}{2}$	0	$\frac{3}{16}$	0
Over 4 in............	$\frac{1}{64}$	$\frac{3}{64}$	22	0	28	0	15	0	$17\frac{1}{2}$	0	$\frac{3}{16}$	0

[a] Including out of roundness measured on any diameter.

[b] The gaging tolerances given apply to each hot-finished or cold-drawn tube before polishing, upsetting, swaging, expanding or other forming operations.

[c] The variation in wall thickness in any section of any one tube shall not exceed ± 10 per cent of the actual average wall of that section. The actual average wall is defined as the average of the thickest and thinnest wall in that section.

[d] Length tolerances apply to tubes before bending.

(*b*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the tubes ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the tubes are being furnished in accordance with these specifications.

Rejection

19. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 5 (*a*) shall be reported to the manufacturer within five working days from the receipt of samples.

(*b*) Tubes which fail in any of the forming operations provided for under Section 13 will be rejected and the manufacturer shall be notified.

Rehearing

20. Samples tested in accordance with Section 5 (*a*) which represent rejected tubes, shall be preserved for two weeks from the date of test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

EXPLANATORY NOTE

NOTE.—For purposes of design, the following tensile properties may be assumed:

Tensile strength, min., lb. per sq. in.	47 000
Yield point, min., lb. per sq. in.	26 000
Elongation in 2 in., min., per cent	35

TENTATIVE SPECIFICATIONS

FOR

SEAMLESS COLD-DRAWN ALLOY-STEEL (4 TO 6 PER CENT CHROMIUM) HEAT-EXCHANGER AND CONDENSER TUBES[1]

A.S.T.M. Designation: A 187 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1936.

By publication of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing the specifications against liability for infringement of Letters Patent nor assume any such liability, and such publication should not be construed as a recommendation of any patented or proprietary application that may be involved.

Scope

1. (*a*) These specifications cover three types of seamless, cold-drawn, alloy-steel tubes ½ in. to but not including 2 in. in outside diameter, for heat exchangers, condensers and similar apparatus for transferring heat: namely,

Type Cr	4.00 to 6.00 per cent chromium
Type CrMo	4.00 to 6.00 per cent chromium, and 0.45 to 0.65 per cent molybdenum
Type CrW	4.00 to 6.00 per cent chromium, and 0.75 to 1.25 per cent tungsten

(*b*) The type and maximum carbon content shall be specified on the order.

(*c*) In specifying dimensions, the purchaser shall specify either outside diameter and minimum wall thickness or outside diameter and average wall thickness. The inside diameter shall not be specified.

Process

2. The steel shall be made by the electric-furnace process or other process approved by the purchaser.

Manufacture

3. (*a*) Tubes shall be made by the seamless process and shall be cold-drawn.

(*b*) Unless otherwise agreed upon by the purchaser and manufacturer, the tubes may be given such heat treatment as is considered desirable by the manufacturer to meet the requirements of these specifications.

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[1] **Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee A-1 on Steel.**

Chemical Composition

4. (*a*) The steel shall conform to the following requirements as to chemical composition:

	TYPE CR	TYPE CRMO	TYPE CRW
Carbon, as specified { max., per cent	0.15	0.15	0.15
Carbon, as specified { max., per cent	0.20	0.20	0.20
Manganese, max., per cent	0.50	0.50	0.50
Phosphorus, max., per cent	0.03	0.03	0.03
Sulfur, max., per cent	0.03	0.03	0.03
Silicon, max., per cent	0.50	0.50	0.50
Chromium, per cent	4.00 to 6.00	4.00 to 6.00	4.00 to 6.00
Molybdenum, per cent	....	0.45 to 0.65	....
Tungsten, per cent	....	....	0.75 to 1.25

(*b*) When requested by the purchaser, the manufacturer shall submit a report showing the ladle analysis of each melt of steel from which the tubes have been made.

Check Analyses

5. (*a*) When requested by the purchaser, analyses of two tubes from each melt or from each lot of 250 tubes or fraction thereof shall be made. Drillings for analysis shall be taken from several points around each tube selected for analysis. The chemical composition thus determined shall conform to the requirements specified in Section 4 (*a*).

(*b*) If the analysis of one tube does not conform to the requirements specified, analyses of two additional tubes from the same lot shall be made, each of which shall conform to the requirements specified in Section 4 (*a*).

Tension Test

6. (*a*) The material shall conform to the following minimum requirements as to tensile properties:

Tensile strength, min., lb. per sq. in.	60 000
Yield point, min., lb. per sq. in.	25 000
Elongation in 2 in., min., per cent	30

(*b*) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine, or other approved method.

Flattening Test

7. (*a*) For tubes having wall thicknesses[1] not exceeding 10 per cent of their outside diameters, a section not less than 2½ in. in length shall stand being flattened between parallel plates until the distance between the plates is three times the wall thickness, without cracking or showing flaws.

(*b*) For tubes having wall thicknesses[1] exceeding 10 per cent of their outside diameters, a section not less than 2½ in. in length shall stand being flattened between parallel plates until the distance between the plates is four times the wall thickness, without cracking or showing flaws.

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[1] The term wall thickness shall be defined as the actual mean wall of the material tested.

Flaring Test

8. (*a*) A section of tube approximately 4 in. in length shall stand being expanded at one end over a tapered mandrel having a slope of 1 in 10 (Fig. 1) until the actual average inside diameter is increased 20 per cent, without cracking or showing flaws.

(*b*) *Alternative Flange Test.*—When specified on the order, a flange test may be substituted for the flaring test prescribed in Paragraph (*a*) for tubes having wall thicknesses[1] less than 10 per cent of the outside diameter. In this case a section of tube not less than 4 in. in length shall be capable of having a flange turned over at right angles to the body of the tube without cracking or showing flaws. This flange as measured from the outside of the tube, shall not be less than $\frac{1}{8}$ in. nor more than $\frac{3}{8}$ in. Within these limits, the width of the flange shall not be less than 15 per cent of the outside diameter of the tube. It is recommended that the flaring tool and die block shown in Fig. 2 be used in making the flange test.

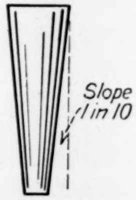

FIG. 1.—Tapered Mandrel for Flaring Test.

(*c*) For tubes heavier than specified in Paragraph (*b*), the flange test shall not be required.

Hardness Test

9. (*a*) A Rockwell test shall show a hardness number not to exceed 85 B Scale.

(*b*) The hardness test may be made on the tube near the end, or on a specimen cut from the tube, at the option of the manufacturer.

(*c*) In making the Rockwell hardness test, reference should be made to the Standard Methods of Rockwell Hardness Testing of Metallic Materials (A.S.T.M. Designation: E 18) of the American Society for Testing Materials.[2]

Hydrostatic Test

10. Each tube shall be tested at the mill and shall withstand a hydrostatic pressure of 1000 lb. per sq. in.

Test Specimens

11. (*a*) Test specimens shall be taken from the ends of finished tubes before being cut to length. They shall be smooth on the ends and free from burrs and flaws.

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[1] The term wall thickness shall be defined as the actual mean wall of the material tested.

[2] 1936 Book of A.S.T.M. Standards, Part I, p. 824.

(*b*) Tension tests shall be made on full sections of the tubes.

(*c*) For tubes with upset ends, all tests specified in Sections 6, 7 and 8 shall be made on the plain end tubes, before upsetting, and the hardness test specified in Section 9 shall be made on the ends, after upsetting.

(*d*) All specimens shall be tested at room temperature.

Number of Tests

12. (*a*) From each group of 100 finished tubes or fraction thereof, one tube shall be selected at random for the tension test specified in Section 6.

(*b*) From each heat treated lot, one flattening and one flaring or flange test specified in Sections 7 and 8 shall be made on each of two tubes and one hardness test specified in Section 9 shall be made on each of 5 per cent of the tubes.

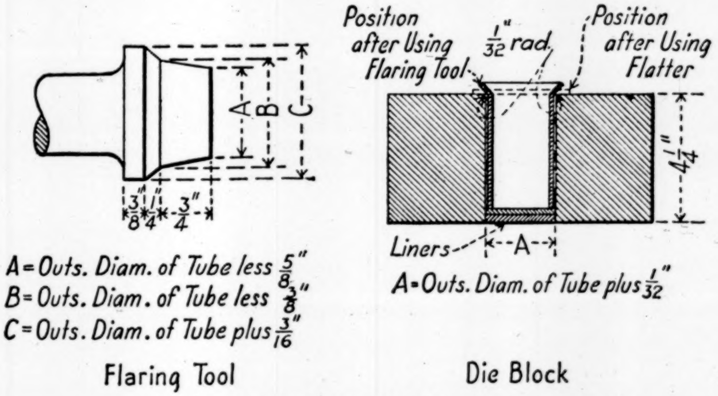
A
B
C
3/8"
1/4"
3/4"
A = Outs. Diam. of Tube less 5/8"
B = Outs. Diam. of Tube less 3/8"
C = Outs. Diam. of Tube plus 3/16"
Flaring Tool
Position after Using Flaring Tool
1/32" rad.
Position after Using Flatter
4 1/4"
Liners
A
A = Outs. Diam. of Tube plus 1/32"
Die Block

FIG. 2.—Flaring Tool and Die Block for Flange Test.

(*c*) Each tube shall be subjected to the hydrostatic test specified in Section 10.

Retests

13. (*a*) If the results of the physical tests of any group or lot do not conform to the requirements specified in Sections 6, 7, 8 and 9, retests may be made on additional tubes of double the original number from that group or lot, each of which shall conform to the requirements specified.

(*b*) If any tension test specimen shows defective machining or develops flaws it may be discarded and another specimen substituted. If the elongation of any tension test specimen is less than that specified, and any part of the fracture is more than ¾ in. from the center of the gage length as indicated by scribe scratches on the specimen before testing, a retest shall be allowed.

Retreatment

14. If a group or lot fails to meet the test requirements specified in Sections 6, 7, 8 and 9, the group or lot represented may be retreated and resubmitted for test. Only two reannealing treatments will be permitted.

Permissible Variations in Dimensions

15. Variations in diameter, wall thickness and length from those specified, shall not exceed the amounts shown in Table I. (See Notes 1 and 2.)

TABLE I.—PERMISSIBLE VARIATIONS IN DIMENSIONS OF TUBES.

Size, Outside Diameter, in.	Outside Diameter (Including Out of Roundness), in.		Inside Diameter,[a] in.		Wall Thickness,[a] per cent		Cut Length, in.	
	Over	Under	Over	Under	Over	Under	Over	Under
PERMISSIBLE VARIATIONS FOR AVERAGE WALL TUBES								
Under 1	0.004	0.004	0.004	0.004	10	10	1/8	0
1 to 1½, incl	0.006	0.006	0.006	0.006	10	10	1/8	0
Over 1½ to 2, excl	0.008	0.008	0.008	0.008	10	10	1/8	0
PERMISSIBLE VARIATIONS FOR MINIMUM WALL TUBES								
Under 1	0.004	0.004	.....	.....	22	0	1/8	0
1 to 1½, incl	0.006	0.006	.....	.....	22	0	1/8	0
Over 1½ to 2, excl	0.008	0.008	.....	.....	22	0	1/8	0

[a] For tubes having an inside diameter less than 60 per cent of the outside diameter or having a wall ¾ in. or over in thickness, which cannot be successfully drawn over a mandrel, the inside diameter may vary over or under by an amount equal to 10 per cent of the wall thickness. The wall thickness of these tubes may vary 12.5 per cent over or under that specified.

For tubes having an inside diameter less than ½ in., which cannot be successfully drawn over a mandrel, the wall thickness may vary 15 per cent over or under that specified; and the inside diameter will be governed by the outside diameter and wall thickness variations.

NOTE.—While the tubes are actually drawn to cold-drawn mechanical tubing tolerances the additional tolerances shown in Table I are required on account of warping caused by annealing and straightening.

Finish

16. Finished tubes shall be reasonably straight and have smooth ends, free from burrs. They shall be free from scale and injurious defects and have a workmanlike finish. Minor defects may be removed by grinding, provided the wall thickness is not decreased to less than that permitted in Section 15. A slight amount of oxidation will not be considered as scale.

Marking

17. The name or brand of the manufacturer, name and order number of the purchaser, type, and hydrostatic test pressure in pounds shall be marked on a tag securely attached to the bundle or box in which the tubes are shipped.

Inspection

18. (*a*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. Unless otherwise specified, inspection and all tests shall be made at the place of manufacture.

Certification

(*b*) When inspection by the purchaser is waived, the manufacturer shall furnish on request a statement that the material has been tested and has met all the requirements of these specifications.

Rejection

19. (*a*) When inspection at the place of manufacture has been waived any rejection based on tests made in accordance with Section 5 shall be reported by the purchaser within five working days from receipt of samples.

(*b*) Tubes which fail in the process of installation shall be set aside and the manufacturer notified.

Rehearing

20. When inspection at place of manufacture has been waived, samples tested in accordance with Section 5, which represent rejected tubes, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

EXPLANATORY NOTES

NOTE 1. *Average Wall.*—When an average wall tube is specified, the theoretical weight per foot of the tube is based on the exact specified dimensions. The actual wall thickness may vary over and under the specified thickness by certain definite amounts.

For the theoretical weight: $W = (D - t)t\ 10.68$
For the nominal inside diameter: $ID = D - 2t$

where W = the weight per foot of tube in pounds
ID = the inside diameter of tube in inches
D = the specified outside diameter of tube in inches
t = the specified wall thickness of tube in inches
10.68 = the weight constant

The actual weight of finished tubes may vary 5 per cent under or 3.5 per cent over the theoretical weight.

NOTE 2. *Minimum Wall.*—When a minimum wall tube is specified, the wall thickness shall at no point be less than that specified, but may exceed that thickness by a certain definite amount. This necessitates establishing a mean wall dimension between the maximum and minimum dimensions.

For cold-drawn tubes the mean wall thickness $= \frac{\text{specified wall thickness}}{0.90}$

Since the wall thickness of the tube has now been increased it follows that the weight per foot has been increased also.

The weight may be determined by the following formula:

For cold-drawn tubes: $W = (D \frac{t}{0.90}) \frac{t}{0.90}\, 10.68$

The actual weight of finished tubes may vary 5 per cent under or 3.5 per cent over this calculated weight.

The nominal inside diameters of minimum wall tubes may be determined by the following formula:

For cold-drawn tubes: $ID = D - 2 \frac{t}{0.90}$

where W = the weight per foot in pounds
ID = the nominal inside diameter of tube in inches
D = the specified outside diameter of tube in inches
t = the specified wall thickness of tube in inches

TENTATIVE SPECIFICATIONS

FOR

SEAMLESS ALLOY-STEEL (4 TO 6 PER CENT CHROMIUM) STILL TUBES FOR REFINERY SERVICE[1]

A.S.T.M. Designation: A 188 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1936.

By publication of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing the specifications against liability for infringement of Letters Patent nor assume any such liability, and such publication should not be construed as a recommendation of any patented or proprietary application that may be involved.

Scope

1. (*a*) These specifications cover three types of seamless, hot-rolled and cold-drawn, alloy-steel still tubes 2 in. or over in outside diameter and thicker than No. 5 B.w.g. in minimum wall or $\frac{1}{4}$ in. in average wall for use in carrying oil at elevated temperatures and pressures in various types of oil stills, in which the tubes may be subjected to a furnace temperature higher than that of the contained fluid: namely,

Type Cr	4.00 to 6.00 per cent chromium
Type CrMo	4.00 to 6.00 per cent chromium, and 0.45 to 0.65 per cent molybdenum
Type CrW	4.00 to 6.00 per cent chromium, and 0.75 to 1.25 per cent tungsten

(*b*) The type and maximum carbon content shall be specified on the order.

(*c*) In specifying dimensions, the purchaser shall specify either outside diameter and minimum wall thickness or outside diameter and average wall thickness. The inside diameter shall not be specified.

Process

2. The steel shall be made by the electric-furnace process or other process approved by the purchaser.

Manufacture

3. (*a*) Tubes shall be made by the seamless process and shall be either hot-rolled or cold-drawn, as specified.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee A-1 on Steel.

(*b*) Unless otherwise agreed upon by the purchaser and manufacturer, the tubes may be given such heat treatment as is considered desirable by the manufacturer to meet the requirements of these specifications.

Chemical Composition

4. (*a*) The steel shall conform to the following requirements as to chemical composition:

	Type Cr	Type CrMo	Type CrW
Carbon, as specified max., per cent	0.15	0.15	0.15
max., per cent	0.20	0.20	0.20
Manganese, max. per cent	0.50	0.50	0.50
Phosphorus, max. per cent	0.03	0.03	0.03
Sulfur, max. per cent	0.03	0.03	0.03
Silicon, max. per cent	0.50	0.50	0.50
Chromium, per cent	4.00 to 6.00	4.00 to 6.00	4.00 to 6.00
Molybdenum, per cent	....	0.45 to 0.65	....
Tungsten, per cent	....	....	0.75 to 1.25

(*b*) The manufacturer shall submit a report showing the ladle analysis of each melt of steel from which the tubes have been made.

Check Analysis

5. (*a*) Analysis of either one billet or one tube from each melt of steel or fraction thereof shall be made. Drillings for analysis shall be taken from several points around each tube selected for analysis. When drillings for analysis are taken from the billet, the sample shall be taken at any point midway between the outside and the center of the piece by drilling parallel to the axis. The chemical composition thus determined shall conform to the requirements specified in Section 4 (*a*).

(*b*) If the analysis of one of these test specimens does not conform to the requirements specified in Section 4 (*a*), analysis of each billet or tube from the same heat may be made, and all billets or tubes thus conforming to the requirements shall be accepted.

Tension Test

6. (*a*) The material shall conform to the following minimum requirements as to tensile properties:

Tensile strength, min., lb. per sq. in.	60 000
Yield point, min., lb. per sq. in.	25 000
Elongation in 2 in., min., per cent	30

(*b*) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine, or other approved method.

Flattening Test

7. (*a*) For tubes having wall thicknesses[1] not exceeding 10 per cent of their outside diameters, a section not less than 2½ in. in length shall stand being flattened between parallel plates until the distance between the plates is three times the wall thickness, without cracking or showing flaws.

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[1] The term wall thickness shall be defined as the actual mean wall of the material tested. (See Notes 1 and 2.)

(*b*) For tubes having wall thicknesses[1] exceeding 10 per cent of their outside diameters, a section not less than 2½ in. in length shall stand being flattened between parallel plates until the distance between the plates is four times the wall thicknesses, without cracking or showing flaws.

Flaring Test

8. A section of tube approximately 4 in. in length shall stand being flared with a tool having a 60-deg. included angle until the tube at the mouth of the flare has been expanded to the following percentages, without cracking or showing flaws:

RATIO OF INSIDE DIAMETER TO OUTSIDE DIAMETER[a]	MINIMUM EXPANSION OF INSIDE DIAMETER, PER CENT
0.9	15
0.8	17
0.7	19
0.6	23
0.5	28
0.4	38
0.3	50

[a] In determining the ratio of inside diameter to outside diameter, the inside diameter shall be defined as the actual mean inside diameter of the material tested. (See Notes 1 and 2.)

Hardness Test

9. (*a*) A Brinell test shall show a hardness number not to exceed the following:

		BRINELL HARDNESS NUMBER
Type Cr	Carbon 0.15 per cent, max	163
	Carbon 0.20 per cent, max	170
Type CrMo	Carbon 0.15 per cent, max	163
	Carbon 0.20 per cent, max	170
Type CrW	Carbon 0.15 per cent, max	170
	Carbon 0.20 per cent, max	179

(*b*) The hardness test may be made on the tube near the end or on a specimen cut from the tube, at the option of the manufacturer.

(*c*) In making the Brinell hardness test, reference should be made to the Standard Methods of Brinell Hardness Testing of Metallic Materials (A.S.T.M. Designation: E 10) of the American Society for Testing Materials.[2]

Hydrostatic Test

10. (*a*) Each tube shall be tested at the mill to a hydrostatic pressure which shall be determined by the following formula:

$$P = \frac{32{,}000\,t}{D}$$

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[1] The term wall thickness shall be defined as the actual mean wall of the material tested. (See Notes 1 and 2.)

[2] 1936 Book of A.S.T.M. Standards, Part I, p. 817.

where P = the hydrostatic test pressure in pounds per square inch;
t = the thickness of tube wall in inches,[1] and
D = the outside diameter of tube in inches.

(*b*) The maximum test pressure shall not exceed 2500 lb. per sq. in. or sizes 3 in. or under in outside diameter, nor 4500 lb. per sq. in. for sizes over 3 in. in outside diameter.

Test Specimens

11. (*a*) Test specimens shall be taken from the ends of the finished tubes before being cut to length. They shall be smooth on the ends and free from burrs and flaws.

(*b*) Tension tests, if desirable and practicable, may be made on full sections of the tubes up to the capacity of the testing machine. For larger size tubes, the tension specimens shall consist of a strip cut longitudinally from the tube and not flattened between gage marks. The sides of the specimen shall be parallel between gage marks; the width, irrespective of the thickness up to and including $\frac{3}{4}$ in. shall be 1 in., and the gage length shall be 2 in. When the wall thickness exceeds $\frac{3}{4}$ in., the standard A.S.T.M. $\frac{1}{2}$-in. round tension test specimen may be used.

(*c*) For tubes with upset ends, all tests specified in Sections 6, 7 and 8 shall be made on the plain end tubes, before upsetting, and the hardness test specified in Section 9 shall be made on the ends, after upsetting.

(*d*) All specimens shall be tested at room temperature.

Number of Tests

12. (*a*) From each group of 100 finished tubes or fraction thereof two tubes shall be selected at random for the tension test specified in Section 6.

(*b*) One flattening and one hardness test specified in Sections 7 and 9 shall be made on each end of each tube.

(*c*) *Alternative.*—When specified on the order, the flaring test specified in Section 8 may be substituted for the flattening test and shall be made on each end of each tube, together with the hardness test, specified in Section 9, on both ends of five tubes from each heat treated lot. In the case of tubes heat treated by the continuous process, the hardness test shall be made on one end of each of 40 per cent or both ends of each of 20 per cent of such tubes.

(*d*) Each tube shall be subjected to the hydrostatic test specified in Section 10.

Retests

13. (*a*) *For Testing by Groups or Lots.*—When the results of the physical tests of any group or lot do not conform to the requirements

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[1] The term wall thickness shall be defined as the actual mean wall of the material tested. (See Notes 1 and 2.)

specified in Sections 6 and 9 (See Section 12 (*c*)), retests may be made on additional tubes of double the original number from the same group or lot, each of which shall conform to the requirements specified.

(*b*) *For Testing Each Tube.*—When individual tubes fail to meet the tests required in Sections 7, 8 and 9 (see Section 12 (*b*) and (*c*)), they may be retested.

(*c*) If any tension test specimen shows defective machining or develops flaws it may be discarded and another specimen substituted.

(*d*) If the elongation of any tension test specimen is less than that specified, and any part of the fracture is more than $\frac{3}{4}$ in. from the center of the gage length as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

TABLE I.—PERMISSIBLE VARIATIONS IN DIMENSIONS AND WEIGHTS OF STILL TUBES.

Size	Permissible Variations											
Outside Diameter, in.	Outside Diameter, in.		Cut Length, in.		When Wall Thickness is Specified as "Minimum"				When Wall Thickness is Specified as "Average"			
					Specified Wall Thickness, per cent		Calculated Weight per Foot, per cent		Specified Wall Thickness, per cent		Theoretical Weight per Foot per cent	
	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under
HOT-ROLLED STILL TUBES												
4 or under	$\frac{1}{64}$	$\frac{1}{32}$	$\frac{3}{16}$	0	28	0	3.5	5	12.5	12.5	3.5	5
Over 4 to 7½, inclusive	$\frac{1}{64}$	$\frac{3}{64}$	$\frac{3}{16}$	0	28	0	3.5	5	12.5	12.5	3.5	5
COLD-DRAWN STILL TUBES[a]												
4 or under	0.015	0.015	$\frac{3}{16}$	0	22	0	3.5	5	10	10	3.5	5
Over 4 to 7½, inclusive	0.015	0.025	$\frac{3}{16}$	0	22	0	3.5	5	10	10	3.5	5

[a] When cold-drawn tubes as ordered require wall thicknesses $\frac{3}{4}$ in. or over, or an inside diameter 60 per cent or less of the outside diameter, the permissible variations in wall thickness for hot-rolled tubes shown in the upper table shall apply.

Retreatment

14. If individual tubes or the tubes selected to represent any group or lot fail to meet the test requirements specified in Sections 6, 7, 8 and 9, the individual tubes or the group or lot represented may be retreated and resubmitted for test. Only two reannealing treatments will be permitted.

Permissible Variations in Dimensions and Weights

15. (*a*) Variations in diameter, wall thickness, weight and length from those specified, shall not exceed the amounts shown in Tables I to III. (See Notes 1 and 2.)

(*b*) If requested by the purchaser, 10 per cent of the finished tubes may be weighed individually or in convenient lots.

(*c*) Tubes shall be of such diameter that a ring gage approximately 1 in. in length with a bore 0.025 in. larger than the specified outside diameter will pass over each end for a distance of 8 in. This permissible variation applies also to the ends of upset tubes.

(*d*) Permissible variations for hot-rolled tubes shall apply to the upset ends of both hot-rolled and cold-drawn tubes.

TABLE II.—PLUG GAGE DIMENSIONS FOR TUBES WITH PLAIN ENDS.

A plug gage 4 in. in length, with a diameter determined by the proper formula given in this table shall enter each end of each tube for a distance of 4 in.

	Outside Diameter, in.	Hot-Rolled Still Tubes	Cold-Drawn Still Tubes
		Formulas[a]	Formulas[a]
When wall thickness is specified as "Minimum"........................	4 or under...............	$PG=D-\frac{2t}{0.875}-0.077$	$PG=D-\frac{2t}{0.90}-0.0625$
	Over 4 to $7\frac{1}{2}$, inclusive...	$PG=D-\frac{2t}{0.875}-0.102$	$PG=D-\frac{2t}{0.90}-0.080$
When wall thickness is specified as "Average"........................	4 or under...............	$PG=D-2t-0.077$	$PG=D-2t-0.0625$
	Over 4 to $7\frac{1}{2}$, inclusive...	$PG=D-2t-0.102$	$PG=D-2t-0.080$

[a] Expressions used in formulas are as follows:
PG = the diameter of plug gage in inches;
D = the specified outside diameter of tube in inches, and
t = the specified thickness of tube wall in inches.

TABLE III.—PLUG GAGE DIMENSIONS FOR TUBES WITH INTERNAL UPSET ENDS.

For tubes which are upset at the ends, a plug gage with a diameter determined by the proper formula given in this table shall enter the upset ends of each tube for a distance equal to the length of the upset.

Length of Upset, in.	Hot-Rolled Still Tubes		Cold-Drawn Still Tubes	
	Formulas[a]		Formulas[a]	
	Minimum Wall	Average Wall	Minimum Wall	Average Wall
3 or under...	$PG=D-2\left(\frac{t}{0.875}+U\right)-0.093$	$PG=D-2(t+U)-0.093$	$PG=D-2\left(\frac{t}{0.90}+U\right)-0.093$	$PG=D-2(t+U)-0.093$
Over 3 to 4, inclusive...	$PG=D-2\left(\frac{t}{0.875}+U\right)-0.113$	$PG=D-2(t+U)-0.113$	$PG=D-2\left(\frac{t}{0.90}+U\right)-0.113$	$PG=D-2(t+U)-0.113$
Over 4 to 5, inclusive...	$PG=D-2\left(\frac{t}{0.875}+U\right)-0.133$	$PG=D-2(t+U)-0.133$	$PG=D-2\left(\frac{t}{0.90}+U\right)-0.133$	$PG=D-2(t+U)-0.133$

[a] Expressions used in formulas are as follows:
PG = the diameter of plug gage in inches;
D = the specified outside diameter of tube in inches;
t = the specified thickness of tube wall in inches, and
U= the increase in tube wall thickness at upset end in inches.

Finish

16. (*a*) Finished tubes shall be reasonably straight and have smooth ends, free from burrs. They shall be free from injurious defects and have a workmanlike finish, Minor defects may be removed by grinding, provided the wall thickness is not decreased to less than that permitted in Section 15.

(*b*) The normal rotary straightening operation shall be deemed sufficient to remove scale for inspection.

Marking

17. (*a*) Tubes shall be marked, by paint stenciling, with the name or brand of the manufacturer (or stamped with his private identifying mark, when specified), name and order number of the purchaser, type, size, and hydrostatic test pressure in pounds, and whether hot-rolled or cold-drawn.

(*b*) If required by the purchaser, and if practicable, the melt number and type of steel shall be stamped on each tube with steel stamps not less than 18 in. from one end.

(*c*) When required by the purchaser, the inside surface of both ends of tubes 3 in. in inside diameter or over shall be marked with paint of the following colors:

Type Cr	Yellow
Type CrMo	Yellow-red
Type CrW	Yellow-blue

Inspection

18. (*a*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. Unless otherwise specified, inspection and all tests shall be made at the place of manufacture.

Certification

(*b*) When inspection by the purchaser is waived, the manufacturer shall furnish, on request, a statement that the material has been tested and has met all the requirements of these specifications.

Rejection

19. (*a*) When inspection at the place of manufacture has been waived, any rejection based on tests made in accordance with Section 5 shall be reported by the purchaser within five working days from receipt of samples.

(*b*) Tubes which fail in the process of installation shall be set aside and the manufacturer notified.

Rehearing

20. When inspection at place of manufacture has been waived, samples tested in accordance with Section 5 which represent rejected tubes, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

EXPLANATORY NOTES

NOTE 1. *Average Wall.*—When an average wall tube is specified, the theoretical weight per foot of the tube is based on the exact specified dimensions. The actual wall thickness may vary over and under the specified thickness by certain definite amounts.

For the theoretical weight: $W = (D - t)t\ 10.68$

For the nominal inside diameter: $ID = D - 2t$

where W = the weight per foot of tube in pounds
ID = the inside diameter of tube in inches
D = the specified outside diameter of tube in inches
t = the specified wall thickness of tube in inches
10.68 = the weight constant

The actual weight of finished tubes may vary 5 per cent under or 3.5 per cent over the theoretical weight.

NOTE 2. *Minimum Wall.*—When a minimum wall tube is specified, the wall thickness shall at no point be less than that specified, but may exceed that thickness y a certain definite amount. This necessitates establishing a mean wall dimension etween the maximum and minimum dimensions.

For hot-rolled tubes the mean wall thickness $= \dfrac{\text{specified wall thickness}}{0.875}$

For cold-drawn tubes the mean wall thickness $= \dfrac{\text{specified wall thickness}}{0.90}$

Since the wall thickness of the tube has now been increased it follows that the weight per foot has been increased also.

The weight may be determined by the following formulas:

For hot-rolled tubes: $W = \left(D - \dfrac{t}{0.875}\right)\dfrac{t}{0.875}\ 10.68$

For cold-drawn tubes: $W = \left(D - \dfrac{t}{0.90}\right)\dfrac{t}{0.90}\ 10.68$

The actual weight of finished tubes may vary 5 per cent under or 3.5 per cent over this calculated weight.

The nominal inside diameters of minimum wall tubes may be determined by the following formulas:

For hot-rolled tubes: $ID = D - 2\dfrac{t}{0.875}$

For cold-drawn tubes: $ID = \mathrm{D} - 2\dfrac{t}{0.90}$

where W = the weight per foot in pounds
ID = the nominal inside diameter of tube in inches
D = the specified outside diameter of tube in inches
t = the specified wall thickness of tube in inches

TENTATIVE SPECIFICATIONS
FOR
ALLOY-STEEL BOLTING MATERIALS FOR HIGH-PRESSURE AND HIGH-TEMPERATURE SERVICE TO 1100 F.[1]

A.S.T.M. Designation: A 193 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1936.[2]

By publication of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing the specifications against liability for infringement of Letters Patent nor assume any such liability, and such publication should not be construed as a recommendation of any patented or proprietary application that may be involved.

Scope

1. (*a*) These specifications cover alloy-steel bolting material for pressure vessels, valves, flanges and fittings for high-pressure and/or high-temperature service. The term "bolting material" as used in these specifications covers rolled, forged or cold-drawn bars, and bolts, screws and studs.

(*b*) Five classes of material are covered: namely, Classes A, B, C, D and E, classified in accordance with their physical properties as specified in Section 10, choice depending upon design and upon the stresses and service for which the material is to be used.

(*c*) Alloy steels containing nickel, chromium, molybdenum, tungsten, vanadium, silicon or manganese in various combinations may be used under these specifications. The manufacturer may select any alloy combination which will meet the given requirements, unless another alloy type which meets these requirements is specified by the purchaser.

(*d*) These specifications cover materials suitable for service up to 1100 F. (see Appendix).

Basis of Purchase

2. When agreed upon between the manufacturer and the purchaser, Brinell hardness tests may be made on Classes A, B, C and D to determine the acceptance of bolting material in lieu of the tension tests herein specified; but shall not be used as a basis for rejection without confirming tension tests being made.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee A-1 on Steel.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 26, 1936.

Certification of Test for Bolts, Screws and Studs

3. Unless otherwise specified on the order, a certification that bolts, screws, and studs for pressure vessels, valves and other fittings intended for stock and other purposes requiring assembly in the manufacturer's plant conform to the requirements of these specifications, shall be accepted in lieu of the tests herein specified.

Process

4. The steel shall be made by one or more of the following processes: open-hearth, electric-furnace or crucible.

Discard

5. A sufficient discard shall be made from each ingot to secure freedom from injurious piping and undue segregation.

Heat Treatment

6. (*a*) Pearlitic steels, Classes A, B, C and D, shall be treated by quenching and tempering. Immediately after rolling or forging, the bolting material shall be allowed to cool to a temperature below the critical range under suitable conditions to prevent injury by too rapid cooling. For quenching and tempering, the material shall then be uniformly reheated to the proper temperature to refine the grain (a group thus reheated being known as a "quenching charge") and quenched in some medium under substantially uniform conditions for each quenching charge. The material shall then be uniformly reheated to the proper temperature for tempering or "drawing back" (a group thus reheated being known as a "tempering charge") and allowed to cool uniformly. The temperature for tempering or drawing back shall be at least 100 F. (38 C.) higher than the proposed operating temperature to which the material will be subjected in service.

(*b*) For austenitic steels, Class E, heat treatment shall consist of stabilizing. The procedure for stabilizing austenitic steels shall consist of allowing the material immediately after rolling or forging to cool at a rate sufficiently rapid to prevent injury to the material; reheating to the proper stabilizing temperature and holding at that temperature for a sufficient time, followed by rapid air cooling or by quenching in a liquid medium.

Chemical Composition

7. (*a*) Except as specified in Paragraphs (*b*) and (*c*), material shall conform to the following requirements as to chemical composition:

Phosphorus, max., per cent	0.045
Sulfur, max., per cent	0.05

(*b*) For austenitic steels, Class E, the following limits for phosphorus and sulfur shall be permitted unless otherwise specified by the purchaser:

Phosphorus, max., per cent	0.140[a]
Sulfur, max., per cent	0.180[a]

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[a] Where phosphorus exceeds 0.045 per cent, sulfur shall not exceed 0.050 per cent. Where sulfur exceeds 0.050 per cent, phosphorus shall not exceed 0.045 per cent.

(*c*) The composition of steel furnished under these specifications, other than phosphorus and sulfur, shall be agreed upon by the manufacturer and the purchaser or may be selected from the five steels[a] listed below in which case the composition shall be within the limits specified for the grade selected:

Class	Ferritic Steels				
Identification Symbol	B4	B5	B7	B11	B13
Grade	Nickel-Chromium-Molybdenum	4 to 6 per cent Chromium	Chromium-Molybdenum	Tungsten-Chromium-Vanadium	Tungsten-Chromium
Carbon, per cent	0.35 to 0.45	0.35 max.	0.35 to 0.45	0.40 to 0.50	0.30 to 0.40
Manganese, per cent	0.50 to 0.80	0.30 to 0.50	0.60 to 0.90	0.20 to 0.40	0.60 to 0.90
Phosphorus, max., per cent	0.04	0.03	0.04	0.04	0.04
Sulfur, max., per cent	0.05	0.03	0.05	0.04	0.04
Silicon, per cent	...	0.50 max.	0.15 to 0.25	0.15 to 0.30	0.15 to 0.30
Nickel, per cent	1.50 to 2.00	...	...	...	...
Chromium, per cent	0.50 to 0.80	4.00 to 6.00	0.80 to 1.10	1.00 to 1.50	0.45 to 0.75
Molybdenum, per cent	0.30 to 0.40	0.45 to 0.65[b]	0.15 to 0.25	...	0.40 to 0.65
Tungsten, per cent	...	0.75 to 1.25[b]	...	1.70 to 2.30	0.85 to 1.35
Vanadium, per cent	...	...	...	0.20 to 0.30	...

[a] As these steels are not necessarily all suitable for the full range of temperature up to 1100 F., care should be exercised in making the selection.

[b] Either molybdenum or tungsten shall be used as specified.

Ladle Analyses

8. An analysis of each melt of steel shall be made by the steel manufacturer to determine the percentages of the specified elements present. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative and shall conform to the requirements as specified on the purchase order.

Check Analyses

9. Analyses may be made by the purchaser from samples representing the bolting material. The chemical composition thus determined shall conform to the requirements specified.

Tension Tests

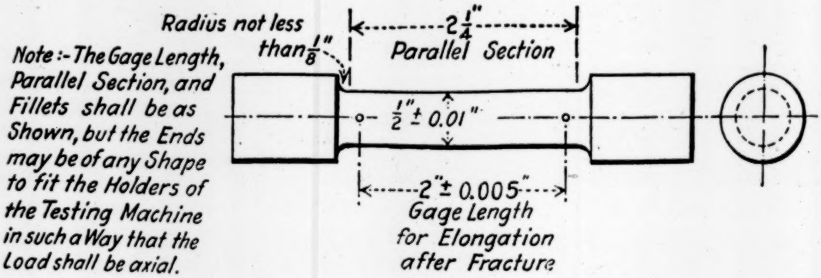
10. (*a*) The bolting material, after final heat treatment, shall conform to the following minimum requirements as to tensile properties at room temperature (see Appendix):

Diameter, in.	Tensile Properties	Class A	Class B	Class C	Class D	Class E
$2\frac{1}{2}$ and under	Tensile strength, min., lb. per sq. in.	95 000	105 000	125 000	135 000	80 000
	Yield point, min., lb. per sq. in.	70 000	80 000	105 000	115 000	35 000
	Elongation in 2 in., min., per cent	20	20	16	15	35
	Reduction of area, min., per cent	50	50	50	45	50
Over $2\frac{1}{2}$ to 4, incl	Tensile strength, min., lb. per sq. in.	90 000	100 000	115 000	125 000	80 000
	Yield point, min., lb. per sq. in.	65 000	75 000	95 000	105 000	35 000
	Elongation in 2 in., min., per cent	20	20	16	15	35
	Reduction of area, min., per cent	50	50	45	45	50
Over 4 to 7, incl	Tensile strength, min., lb. per sq. in.	90 000	100 000	110 000	115 000	80 000
	Yield point, min., lb. per sq. in.	65 000	75 000	85 000	95 000	35 000
	Elongation in 2 in., min., per cent	20	20	16	15	35
	Reduction of area, min., per cent	50	50	45	40	50

(*b*) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine, or by the use of dividers or other approved method, at a crosshead speed of not to exceed $\frac{1}{8}$ in. per min. Where a definite yield point is not exhibited, the yield strength corresponding to a limiting permanent set of 0.2 per cent of the gage length of the specimen, shall be reported instead. The "offset method" of determining yield strength as described in the Standard Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8) of the American Society for Testing Materials[1] shall be followed. The tensile strength shall be determined at a crosshead speed of not to exceed $1\frac{1}{2}$ in. per min.

Test Specimens

(*c*) The tension test specimen taken from bar stock, the finished bolt, screw, or stud shall conform to the dimensions shown in Fig. 1.


Radius not less than $\frac{1}{8}$"
$2\frac{1}{4}$" Parallel Section
$\frac{1}{2}$" ± 0.01"
2" ± 0.005" Gage Length for Elongation after Fracture

Note:-The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 1.—Standard 2-in. Gage Length Tension Test Specimen.

(*d*) In the case of small sections which will not permit of taking the standard tension test specimen specified in Paragraph (*c*), the tension test specimen shall be as large as feasible and its dimensions shall be proportional to those shown in Fig. 1. The gage length for measuring elongation shall be four times the diameter of the specimen.

(*e*) Specimens for tension tests shall be taken longitudinally. For sizes under $1\frac{1}{2}$ in. in diameter the full section shall be machined to conform to requirements specified in Paragraph (*c*). For sizes $1\frac{1}{2}$ in. and larger the specimen shall be taken half way between the center and surface.

Number of Tests

11. (*a*) For bars, one tension test shall be made from each tempering charge. If more than one quenching charge is represented in a tempering charge, one tension test shall be made from each quenching charge. If more than one melt is represented in a quenching charge, one tension test shall be made from each melt.

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[1] 1936 Book of A.S.T.M. Standards, Part I, p. 833.

(*b*) Except as specified in Paragraph (*c*), one tension test shall be made for each lot of 300 pieces or fraction thereof of bolts, screws and studs for sizes up to and including $2\frac{1}{2}$ in. in diameter; or for each lot of 100 pieces or fraction thereof for sizes over $2\frac{1}{2}$ in.

(*c*) Unless required on the order, tension tests shall not be made on an order of less quantity than specified in Paragraph (*b*); in which case acceptance shall be based upon the provisions in Sections 2 or 3.

(*d*) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(*e*) If the percentage of elongation of any tension test specimen is less than that specified in Section 10 (*a*) and any part of the fracture is more than $\frac{3}{4}$ in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

Retests

12. If the results of the physical tests of any test lot do not conform to the requirements specified, the manufacturer may retreat such lot not more than twice, in which case two additional tension tests shall be made from such lot, all of which shall conform to the requirements specified.

Brinell Hardness Test

13. (*a*) When Brinell hardness tests are made, the bolting material, after final heat treatment, shall conform to the following requirements:

	SURFACE BRINELL HARDNESS NUMBER
Class A	190 to 250
Class B	210 to 270
Class C	260 to 320
Class D	280 to 340

(*b*) The Brinell hardness test shall be made in accordance with the Standard Methods of Brinell Hardness Testing of Metallic Materials (A.S.T.M. Designation: E 10) of the American Society for Testing Materials.[1]

Threads

14. (*a*) The threads on bolts, screws, and studs shall be in accordance with the American Standard for Screw Threads (A.S.A. No.: B1.1–1935).

(*b*) All threads shall be formed after heat treatment.

Finish

15. Bolts, screws, and studs shall be pointed and shall have a workmanlike finish.

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[1] 1936 Book of A.S.T.M. Standards, Part I, p. 817.

Marking

16. (*a*) The serial marking for identification of the class of material and the manufacturer's identification mark shall be stamped on the top of the head of bolts and screws, and on one end of studs. The serial marking to be used for "Class" identification shall be as follows:

	MARKING FOR CLASS IDENTIFICATION
Class A	BA
Class B	BB
Class C	BC
Class D	BD
Class E	BE

(*b*) Material ordered in accordance with one of the specific analyses listed in Section 7 (*c*) shall be marked in accordance with the identification symbol shown there.

Inspection

17. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the bolts, screws, and studs ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the bolts, screws, and studs are being furnished in accordance with these specifications. All tests (except check analysis) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection

18. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 9 shall be reported to the manufacturer within five working days from the receipt of samples.

(*b*) Bolts, screws, or studs which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected and the manufacturer will be notified.

Rehearing

19. Samples tested in accordance with Section 9 which represent rejected bolts, screws or studs shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the test, the manufacturer may make claim for a rehearing within that time.

APPENDIX

Data relative to the chemical compositions and physical properties of several alloy-steel bolting materials for service at high temperatures and pressures which are available are given in the following Tables I and II and are submitted as information in connection with Sections 1 (*c*), 7 (*c*) and 10 (*a*) of these specifications.

TABLE I.—CHEMICAL COMPOSITIONS OF SEVERAL STEELS OFFERED FOR HIGH-TEMPERATURE SERVICE.[a]

Class	Ferritic Steels			Austenitic Steel
Identification Symbol	B6	B7a	B12	B8
Grade	13 per cent Chromium	Chromium-High Molybdenum	Chromium-Silicon-Tungsten	18 Chromium-8 Nickel
Carbon, per cent	0.12 max.	0.35 to 0.45	0.40 to 0.60	0.07 max.
Manganese, per cent	0.60 max.	0.60 to 0.90	0.20 to 0.60	0.20 to 0.70
Phosphorus, max., per cent	0.03	0.04	0.03	0.03
Sulfur, max., per cent	0.03	0.05	0.03	0.03
Silicon, per cent	0.50 max.	0.15 to 0.25	3.00 to 3.50	0.75 max.
Nickel, per cent	...	...	...	7.00 to 10.0
Chromium, per cent	11.5 to 13.0	0.80 to 1.10	8.00 to 10.0	17.0 to 20.0
Molybdenum, per cent	...	0.45 to 0.65	...	...
Tungsten, per cent	...	...	1.25 to 1.75	...
Vanadium, per cent	...	...	...	...

[a] These are in addition to the five grades given in Section 7 (*c*) of the specifications.

TABLE II.—ADDITIONAL DATA ON PHYSICAL PROPERTIES FOR STEELS REFERRED TO IN TABLE I AND SUGGESTED HEAT TREATMENTS.

NOTE 1.—The data below are for bolts of diameters 2 in. and under. For larger diameters, a suitable reduction in physical properties should be made a matter of agreement between the purchaser and the manufacturer.

NOTE 2.—These physical properties in Table II and the compositions listed in Table I are tentative and as such are subject to revision and additions from time to time.

Grade	Tensile Strength, lb. per sq. in.	Yield Point, lb. per sq. in.	Elongation in 2 in., per cent	Reduction of Area, per cent	Heat Treatment, deg. Fahr.	
					Quench	Draw
B4	170 000 150 000 130 000	150 000 135 000 110 000	12 15 16	45 50 52	1525 oil quench	1000 1100 1200
B5	110 000 105 000 100 000	90 000 85 000 80 000	12 15 18	50 52 55	1600 water quench	1000 1100 1200
B6	165 000 125 000 105 000	140 000 105 000 85 000	15 17 19	55 60 65	1750 oil quench	1000 1100 1200
B7	160 000 130 000 120 000	140 000 110 000 100 000	12 15 18	45 50 55	1550 oil quench	1000 1100 1200
B7a	Physical Properties for Grade B7a to be added later					
B8	80 000	30 000	35	50	Annealed 2000 F. water quench	
B11	210 000 205 000 185 000	190 000 180 000 165 000	11 12 13	35 35 40	1750 oil quench	1000 1100 1200
B12	190 000 175 000	150 000 135 000	12 15	30 30	1900 oil quench	1000 1100 1200
B13	170 000 135 000 125 000	145 000 115 000 105 000	13 15 18	40 45 52	1600 oil quench	1000 1100 1200

TENTATIVE SPECIFICATIONS
FOR
CARBON AND ALLOY-STEEL NUTS FOR BOLTS FOR HIGH-PRESSURE AND HIGH-TEMPERATURE SERVICE TO 1100 F.[1]

A.S.T.M. Designation: A 194 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1936.[2]

By publication of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing the specifications against liability for infringement of Letters Patent nor assume any such liability, and such publication should not be construed as a recommendation of any patented or proprietary application that may be involved.

Scope

1. (*a*) These specifications cover steel nuts for bolts used in high-pressure or high-temperature service, or both, up to 1100 F.

(*b*) Five classes of material for services varying in degree of severity are covered: Class 0 for service under the least exacting conditions, Class 3 for service under the most severe conditions, and Classes 1, 2 and 2H for service conditions between these extremes.

Certification of Test

2. Where mutually agreed upon in writing between the manufacturer and the purchaser, a certification that the material conforms to the requirements specified may be the basis of acceptance of the material. Otherwise, the manufacturer shall report to the purchaser or his representative the results of the physical tests made in accordance with these specifications and, when required on the purchase order, the chemical analysis also.

Process

3. The steel shall be made by one or more of the following processes: open-hearth, electric-furnace, or acid-bessemer.

Fabrication

4. (*a*) Class 0 nuts shall be made by the hot-forged process, cold process, or machined from bar stock.

(*b*) Classes 1 and 2 nuts shall be made by the hot-forged or cold processes, or machined from hot-forged or hot-rolled bars.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee A-1 on Steel.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 26, 1936.

(*c*) Classes 2H and 3 nuts shall be made by the hot forged or cold processes, or machined from hot-forged or hot-rolled bars and shall be heat treated to meet the required physical properties.

Stress Relieving

5. (*a*) Before tapping, all nuts, excepting Class 0, made by the cold process shall be heated in the process of manufacturing to a temperature of at least 1000 F. (538 C.).

(*b*) Nuts made by the hot process or from hot-forged or hot-rolled bars need not be subjected to this stress relieving.

Chemical Composition

6. Classes 0, 1, 2, 2H and 3 analyses will be furnished the purchaser only when specified on the order, and shall conform to the following requirements as to chemical composition for the respective classes:

	CLASS 0	CLASS 1	CLASSES 2 AND 2H	CLASS 3[a]
Carbon, per cent	0.25 max.	0.25 min.	0.40 min.	0.20 min.
Chromium, per cent	....	....	....	4.0 to 6.0
Molybdenum, per cent	....	....	....	0.45 to 0.65[b]
Tungsten, per cent	....	....	....	0.75 to 1.25[b]
Phosphorus, max., per cent	0.10	0.05	0.05	0.05
Sulfur, max., per cent	0.15	0.05	0.05	0.05

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[a] Other types of alloy steel, with their appropriate heat treatments, approved by the purchaser may be submitted under these specifications.

[b] Either molybdenum or tungsten may be used, if desired.

Ladle Analysis

7. (*a*) A carbon determination of each melt of bessemer steel shall be made, and determinations for manganese, phosphorus and sulfur representing the average of the melts applied for each 8-hr. period.

(*b*) An analysis of each melt of open-hearth or electric-furnace steel shall be made to determine the percentage of carbon, manganese, phosphorus, sulfur or each alloy used.

(*c*) The analysis prescribed in Paragraph (*b*) shall be made by the manufacturer from test ingots taken during the pouring of each melt. When specified on the purchase order, the results of this analysis shall be reported to the purchaser or his representative and the chemical composition thus determined shall conform to the requirements specified in Section 6.

Check Analysis

8. An analysis may be made by the purchaser from a finished nut representing each melt. The phosphorus and sulfur content thus determined shall not exceed that specified in Section 6 by more than 25 per cent, and the other elements shall conform to the specified requirements.

Brinell Hardness Test

9. (*a*) Class 0 nuts in the condition as manufactured shall show a minimum Brinell hardness of 120.

(*b*) Samples of each class of nuts, except Class 0 shall show the Brinell hardness specified below: (*1*) in the finished condition; (*2*) after the sample has been subjected for 24 hr. to a temperature of 850 F. (455 C.) for Class 1, 1000 F. (540 C.) for Classes 2 and 2H, and 1100 F. (590 C.) for Class 3, and then cooled slowly:

	MINIMUM BRINELL HARDNESS	
CLASS	SAMPLE NUT AS FINISHED	SAMPLE NUT AFTER TREATMENT AS IN PARAGRAPH (*b*)
1	150	150
2	160	160
2H	250	180
3	250	200

(*c*) Brinell hardness tests shall be made in accordance with the Standard Methods of Brinell Hardness Testing of Metallic Materials (A.S.T.M. Designation: E 10) of the American Society for Testing Materials.[1]

Drift Test

10. Nuts shall be capable of meeting the following drift test: A conical mandrel, part of which has a diameter equal to the nominal nut size, shall be forced through the tapped hole to the nominal nut size, cold, without cracking the body of the nut. The test may be continued until the nut is broken for examination of the structure.

Stripping Test

11. Nuts of Classes 1, 2, 2H and 3 shall be capable of meeting the following stripping test: A nut shall be assembled on a piece of bolting material held in a tension testing machine so that a load is applied to the nut. The threads in the nut shall not strip when subjected to a stress equal to 150,000 lb. per sq. in. figured from the mean diameter[2] of the bolt.

Number of Tests

12. When so specified on the purchase order, the purchaser's representative may select two nuts per keg for sizes $\frac{5}{8}$ in. and smaller, one nut per keg for sizes over $\frac{5}{8}$ in. up to and including $1\frac{1}{2}$ in., and one nut per every two kegs for sizes larger than $1\frac{1}{2}$ in., and they shall be subjected to the tests specified in Sections 9, 10, and 11. Periodic control tests when made by the manufacturer on each lot of nuts may be considered sufficient for certification purposes in accordance with Section 2.

Retest

13. If the results of any physical test do not conform to the requirements specified, two additional tests from the same lot shall be made, each of which shall conform to the requirements specified.

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[1] 1936 Book of A.S.T.M. Standards, Part I, p. 817.

[2] Mean diameter is the average of the root and pitch diameters.

Finish

14. Nuts shall be free from injurious defects and shall have a workmanlike finish.

15. (*a*) Nuts shall be semifinished, hexagonal in shape and in accordance with the dimensions for the Regular or Heavy Series, as required, of the American Standard for Wrench-Head Bolts and Nuts and Wrench Openings (A.S.A. No.: B18.2–1933). Unless otherwise specified, the American Standard Heavy Series shall be used.

(*b*) The threads in nuts shall be in accordance with the American Standard for Screw Threads (A.S.A. No.: B1.1–1935).

(*c*) Nuts for use with American Standards for pipe flanges and flanged fittings shall have dimensions in accordance with the Heavy Series of the American Standard for Wrench-Head Bolts and Nuts and Wrench Openings (A.S.A. No.: B18.2–1933). Threads in accordance with the American Standard coarse-thread series shall be used except that nuts of sizes 1⅛ in. and larger for use with the American Standard for Steel Flanged Fittings and Companion Flanges (A.S.A. No.: B16e–1932) shall be threaded in accordance with the American Standard 8-Pitch-Thread Series.

Marking

16. (*a*) All nuts shall bear the manufacturer's identification mark.

(*b*) Nuts shall be legibly stamped to indicate the class and the process of manufacture, as follows:

	MARKING	
CLASS	NUTS HOT FORGED OR COLD PUNCHED	NUTS MADE FROM BAR STOCK
0	no marking	0
1	1	1B
2	2	2B
2H	2H[a]	2HB[a]
3	3	3B

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[a] The letter H indicates heat-treated nuts (see Sections 4 (c) and 6).

Inspection

17. (*a*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the nuts ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the nuts are being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made in the presence of the purchaser's representative and shall be made prior to shipment.

(*b*) The purchaser may make, at his own expense, in his own laboratory or elsewhere, additional tests in accordance with these specifications to govern the acceptance or rejection of the nuts.

Rejection

18. Unless otherwise specified, any rejection based on tests made in accordance with these specifications shall be reported to the manufacturer within twelve working days from the receipt of samples.

Rehearing

19. Nuts that have been rejected shall be preserved for two weeks from the date the test report is submitted to the manufacturer. In case of dissatisfaction with the results of test, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS

FOR

20 PER CENT CHROMIUM, 9 PER CENT NICKEL ALLOY-STEEL CASTINGS[1]

A.S.T.M. Designation: A 198 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1936.[2]

By publication of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing the specifications against liability for infringement of Letters Patent nor assume any such liability, and such publication should not be construed as a recommendation of any patented or proprietary application that may be involved.

Scope

1. These specifications cover alloy-steel castings of the 20 per cent chromium, 9 per cent nickel type, for corrosion-resisting service.

Process

2. The steel shall be made by the electric-furnace process, or other process approved by the purchaser.

Heat Treatment

3. (*a*) All castings shall receive a heat treatment proper to the design and section of the casting, except as specified in Paragraph (*c*).

(*b*) Heat treatment shall consist of heating to a sufficiently high temperature for a sufficient time to insure the solution of the carbides followed by a rate of cooling sufficiently great to insure their retention in solution.

(*c*) In the case of certain designs, castings which may become distorted to an objectionable extent by water quenching or those in which the cross-section at any point exceeds 3 in. in thickness need not be heat treated, provided the carbon content does not exceed 0.10 per cent or provided one of the stabilizing elements (Note 1) is present in proper amount.

(*d*) In the case of certain designs where relief of quenching strains is desired, the castings may be drawn at a temperature not to exceed 800 F. (425 C.) for a period of not more than 2 hr.

NOTE 1.—Elements used for stabilizing are molybdenum, tungsten, titanium, columbium and vanadium. In cases when preferred, the stabilizing effect may be obtained by increasing the chromium content to a minimum of 28.0 per cent; the resultant physical properties being as specified in the Tentative Specifications for 28 per cent Chromium, 9 per cent Nickel Alloy-Steel Castings (A.S.T.M. Designation: A 173 – 35 T) of the American Society for Testing Materials.[1]

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys.

[2] Accepted for publication as tentative by Committee E-10 on Standards, October 14, 1936.

Chemical Composition

4. (*a*) The castings shall conform to the requirements as to chemical composition of either of the two following grades, as specified:

	GRADE A (LOW CARBON)	GRADE B
Carbon, max., per cent	0.07	0.20
Chromium, min., per cent	18.0	18.0
Nickel, min., per cent	8.0	8.0
Manganese, max., per cent	1.00	1.00
Silicon, max., per cent	2.00	2.00
Sulfur, max., per cent	0.050	0.050
Phosphorus, max., per cent	0.050	0.050

NOTE.—Molybdenum (2.00 to 4.00 per cent) is sometimes employed for particular and more severe general corrosive conditions, and may be specified by agreement between the manufacturer and the purchaser.

(*b*) When the purchaser requires free-machining or better non-seizing, non-galling properties, the composition may contain suitable combinations of selenium, phosphorus, molybdenum or sulfur, as follows:

SUGGESTED COMBINATIONS		
Selenium and Phosphorus	Selenium, per cent	0.20 to 0.35
	Phosphorus, max., per cent	0.17
Molybdenum and Sulfur	Molybdenum, per cent	0.40 to 0.80
	Sulfur, per cent	0.20 to 0.40

(*c*) For castings which are to be welded without subsequent heat treatment, or which are to serve under severe corrosive conditions, within the range of 800 to 1500 F. (425 to 815 C.), one of the additional elements mentioned in Note 1, Section 3, may be employed, and preferably with Grade A.

Ladle Analysis

5. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements specified in Section 4 (*a*) and (*b*). This analysis shall be made from drillings taken at least $\frac{1}{4}$ in. beneath the surface of the test ingot poured to represent the melt. The chemical composition thus determined shall be reported to the purchaser or his representative and shall conform to the requirements specified in Section 4 (*a*) and (*b*).

Check Analysis

6. Analysis may be made by the purchaser from drillings taken from broken tension test specimens or from a representative casting for the particular melt required, employing the precaution of obtaining drillings at least $\frac{1}{4}$ in. beneath the surface.

Tension Tests

7. (*a*) When specified (see Section 10 (*a*) and Note 1, Section 3), the castings shall conform to the following requirements as to tensile properties:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 645 (1935); also 1936 Book of A.S.T.M. Tentative Standards, p. 148.

Tensile strength, min., lb. per sq. in.	70 000
Yield point, min., lb. per sq. in.	30 000
Elongation in 2 in., min., per cent	35.0
Reduction of area, min., per cent	40
Brinell hardness number, max	200

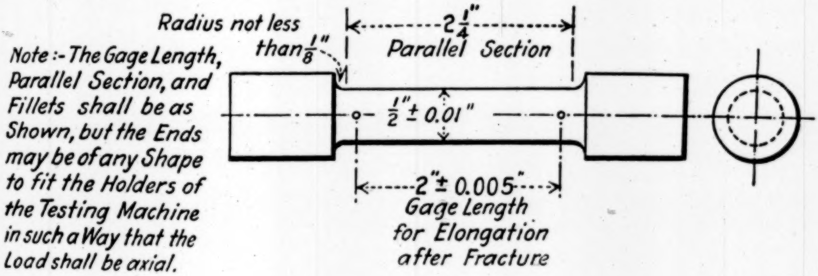
(*b*) The yield point shall be determined by the dividers method using a cross-head speed of not to exceed $\frac{1}{8}$ in. per min. The tensile strength shall be determined at a speed of head of not to exceed $1\frac{1}{2}$ in. per min.

Bend Tests

8. Bend tests shall be required only when so specified. When a bend test is specified, the test specimen shall stand being bent cold through an angle of 120 deg. around a pin 1 in. in diameter without cracking on the outside of the bent portion.

Test Specimens

9. (*a*) Tension and bend test specimens, when required, shall be taken from test bars attached to separately cast blocks, a sufficient number of which shall be provided for each melt. In the case of castings for unusual or severe service, and where practicable, test blocks shall be required to be attached to the castings, when so stated in the inquiry or order.



Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

Radius not less than $\frac{1}{8}$"
$2\frac{1}{4}$"
Parallel Section
$\frac{1}{2}$" ± 0.01"
2" ± 0.005"
Gage Length for Elongation after Fracture

FIG. 1.—Standard 2-in. Gage Length Tension Test Specimen.

(*b*) Tension test specimens shall conform to the dimensions shown in Fig. 1.

(*c*) Bend test specimens shall be machined to 1 by $\frac{1}{2}$ in. in section with the long edges rounded to a radius not over $\frac{1}{16}$ in.

Number of Tests

10. (*a*) Since resistance to corrosion is usually the prime consideration in this alloy, tension tests shall be required only when specified in the inquiry or order. In such cases, one tension test shall be required from each melt.

(*b*) When specified, one bend test only will be required for each melt.

(*c*) If any test specimen shows defective machining or develops flaws, it may be discarded, in which case another specimen from the same lot shall be substituted.

(*d*) If the percentage of elongation of any tension specimen is less than that specified in Section 7 (*a*) and any part of the fracture is more than ¾ in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

Retests

11. If the results of the physical tests for any lot do not conform to the requirements specified, such lot may be reheat-treated, but not more than twice. Retests shall be made as specified in Sections 7 and 8.

Corrosion Test

12. In view of the lack of satisfactory standardization of corrosion tests at this time, and with the realization that this alloy may be employed for many applications involving resistance to corrosion under varying conditions, no specific corrosion test is required under these specifications. By agreement between the manufacturer and the purchaser, however, a corrosion test representative of the service conditions expected, may be employed for establishing the suitability of this material for the particular application contemplated.

Test for Stability of Microstructure

13. (*a*) Castings which are joined by welding, or which in service will be held within a temperature range of 800 to 1500 F. (425 to 815 C.) for short or long periods, without subsequently being heat treated as in Section 3 (*b*), may fail prematurely due to intergranular corrosion, if the corroding medium is sufficiently active. For either or both of these cases the weld-effect test (Note 2) may, by agreement between the manufacturer and the purchaser, be required to demonstrate satisfactory resistance of the casting to such type of corrosion.

NOTE 2.—A test that is advocated by some consumers who have had satisfactory experiences with it is conducted as follows: The test consists of sensitizing a machined specimen 1 in. in width, ⅜ in. in thickness, and 6 in. in length, with the long edges rounded to a radius not over $\frac{1}{16}$ in., by heating to 1200 F. (650 C.), and holding for 10 min. at this temperature followed by cooling in air. A section cut from this specimen is then polished and submitted to the sodium cyanide electrolytic etch test by immersing it as the anode in an electrolyte consisting of 10 g. of c.p. sodium cyanide, in 90 ml. of water, with a piece of the same or similar material as a cathode. An electrode spacing of 1 in. is sufficient, and a direct current with not over 6 v. nor less than 5 v. shall be passed for 5 min. The material is generally considered acceptable if under this test metallographic examination reveals no carbides or if those present are in a highly dispersed form.

(*b*) Should there be any question as to the interpretation of the etch test with respect to acceptability of material involved, the sensitized specimen, or another from the same lot or melt shall be boiled for 72 consecutive hours in a solution of the following composition:

Copper sulfate ($CuSC_4 \cdot 5\,H_2O$, c.p.)	3 g.
Sulfuric acid (c.p., sp. gr. 1.84)	10 ml.
Water (distilled)	87 ml.

A suitable flask, fitted with a reflux condenser, to prevent variations in concentrations, shall be used. After this treatment, the specimen shall be bent 120 deg. to a radius not greater than 1½ times its thickness. Material shall be rejected, if after bending, cracks are visible under low magnification (× 20).

Workmanship

14. The castings shall conform substantially to the shapes and sizes indicated by the patterns and the drawings submitted by the purchaser.

Finish

15. The castings shall be clean and free from any adhering scale. Defects such as seams, folds, pits, etc., that are more than superficial and which may be injurious to the service life of the casting, will be sufficient cause for rejection.

Welding

16. Defects which do not impair the strength of the castings for the purpose intended, may be welded (after cleaning out to solid metal), by an approved process. The deposited metal shall have a resistance to corrosion at least equivalent to that of the base or parent metal. All castings shall be reheat-treated after welding, excepting those governed by Section 3 (*c*).

Marking

17. Where practicable, castings shall be permanently marked by cast symbols or by stamping in such position as not to injure the usefulness of the casting, with the manufacturer's symbol or name, and also a designation to indicate the type or composition of the metal.

Inspection

18. (*a*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the castings ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the castings are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

(*b*) If, in the case of important castings for special purposes, surface inspection in the green state is required, this shall be so specified in the order.

Rejection

19. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 6 shall be reported to the manufacturer within twelve working days from the receipt of samples.

(*b*) Castings which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected and the manufacturer shall be notified.

Rehearing

20. Samples tested in accordance with Section 6, which represent rejected castings, shall be preserved for two weeks from the date of transmission of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE METHOD OF TEST
FOR
UNIFORMITY OF COATING BY THE PREECE TEST (COPPER SULFATE DIP) ON ZINC-COATED (GALVANIZED) IRON OR STEEL WIRE[1]

A.S.T.M. Designation: A 191 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1936.

Scope

1. This method, known as the Preece test, covers the testing procedure for determining uniformity of the zinc coating (galvanizing) on iron or steel wire by the use of a solution of copper sulfate.

Nature of Test

2. This test is designed as a factory inspection or acceptance test on new material. It is useful only for determining which are the thinnest portions of the coating. The fact that different processes of galvanizing produce coatings having widely varying rates of solubility in the copper sulfate solution precludes the use of the Preece test for determining relative weights of coating.[2,3]

Copper Sulfate Solution

3. The copper sulfate solution shall be made by dissolving approximately 36 parts by weight of commercial copper sulfate crystals in 100 parts by weight of distilled water. Heat may be used to complete the solution of the copper sulfate crystals. If heated, the solution shall be allowed to cool. The solution shall then be shaken with an excess of powdered cupric hydroxide ($Cu(OH)_2$) (see Note 1). The presence of an excess of copper hydroxide will be shown by the sediment of this reagent at the bottom of the vessel. The neutralized solution shall be filtered or allowed to settle and decanted.

Specific Gravity of Solution

4. The test solution shall have a specific gravity of 1.186 (22.7° Baumé) at 65 F. (18 C.). If the solution is high in specific gravity, dis-

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee A-5 on Corrosion of Iron and Steel.

[2] H. H. Walkup and E. C. Groesbeck, "Some Factors Affecting the Preece Test for Zinc Coatings," *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part II, p. 456 (1932).

[3] H. H. Walkup and E. C. Groesbeck, "Preece Test for Zinc Coating," National Bureau of Standards *Journal of Research*, Vol. 12, June, 1934, p. 785.

tilled water shall be added to reduce the specific gravity to 1.186 at 65 F. (18 C.). If the solution is low in specific gravity, solution of a higher specific gravity shall be added until the correct specific gravity is obtained.

Rinse Water

5. The rinse water may be ordinary tap water, and shall have a temperature of from 60 to 70 F. (15 to 21 C.). In conducting a series of tests, the rinse water shall be changed often enough to insure that it is reasonably free from copper sulfate.

Quantity of Solution

6. Wire specimens shall be tested in a glass container of at least 2 in. in inside diameter for No. 12-gage wire and smaller and of at least 3 in. in inside diameter for wire larger in diameter than No. 12 gage. The container shall be filled with fresh test solution to a depth of at least 4 in. This quantity of solution shall be used for the simultaneous testing of one to seven test specimens. After completion of the test, the solution shall be discarded and a fresh solution used for any additional tests. The test specimens shall not be allowed to touch each other or the sides of the container.

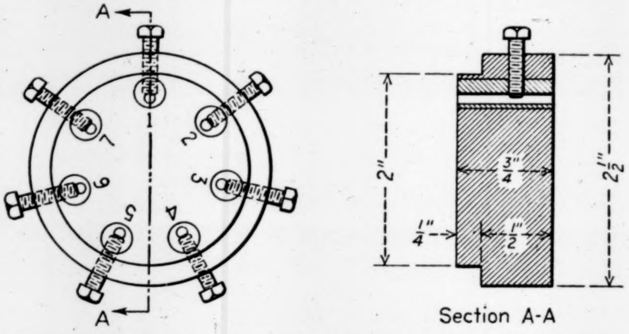

FIG. 1.—Recommended Device for Holding Test Specimens.
Use Non-Conductor Material.

Test Specimens

7. The specimens of wire selected for test shall be free from abrasion or cuts in the zinc coating, and may be hand straightened. The specimens shall be cleaned with alcohol, carbon tetrachloride, gasoline or benzol, and wiped dry with clean white cotton waste, rinsed in water and again dried.

Procedure

8. (*a*) The test specimens shall be placed in the copper sulfate solution which shall be at a temperature of 62 to 68 F. (17 to 20 C.), inclusive. The specimens shall be allowed to remain in a fixed position in the solution for exactly 1 min. (see Fig. 1, showing recommended device for use in

holding test specimens). After each dip the specimens shall immediately be washed in rinse water and wiped dry with clean white cotton waste.

(*b*) Successive dips of 1 min. each shall be continued, with washing and wiping of the test specimens after each dip, until the specimens have withstood the required number of dips, or until the appearance of bright adherent copper indicates that the iron or steel beneath the coating has been exposed. When material is tested by the Preece or copper sulfate dip test, the number of 1-min. immersions which the test specimen shall withstand is specified. The $\frac{1}{2}$-min. dip or dips, if specified, shall be given the test specimen after the completion of all of the 1-min. dips. Should a small amount of copper be coated adherently to the zinc coating, it must not be mistaken for the end point in which the copper plates out onto the iron or steel. The appearance of copper within 1 in. of the cut end of the specimen shall likewise not be considered to be the end point of the test. (See Notes 2 and 3.)

(*c*) *Standard for Comparison.*—In order to determine, in doubtful cases, the appearance of the bright metallic copper deposit which indicates exposed iron or steel, a standard for comparison may be made by dipping a bare steel surface in the copper sulfate solution. The bare steel surface shall be obtained by dipping a sample of the zinc-coated wire, to a depth of 3 in. in strong hydrochloric acid until the violent action ceases, after which this sample shall immediately be washed, wiped dry and dipped for a few seconds in the copper sulfate solution at the specified dipping temperature, then removed, washed and wiped dry. When dipping the bare wire a portion of the zinc coating on the wire shall be immersed in the copper sulfate solution. This copper-coated standard shall be prepared at the time the tests are made.

EXPLANATORY NOTES

NOTE 1.—Copper oxide may be substituted for cupric hydroxide providing the solution is allowed to stand not less than 48 hr. after this addition before decanting or filtering to allow it to come to a constant pH value.

NOTE 2.—As pointed out in Sections 1 and 2, this test is designed as a factory inspection or acceptance test on new material. However, cases may arise where, by reason of unusual surface conditions, the copper sulfate solution will not act normally on the zinc coating. For example, the solution may have no apparent attack on all or part of the surface, or false deposits of copper may appear on the zinc coating. In all such cases the test specimens shall be cleaned in alcohol, rinsed and wiped dry and then immersed for 3 min. in a solution consisting of one part by volume of ammonium hydroxide (sp. gr. 0.90) and nine parts of water, during which time the specimens may be scrubbed with cotton waste; after cleaning, the specimens shall be washed and wiped dry.

NOTE 3.—After the first or successive dips, premature end points, that is, adherence of dull copper before the underlying steel is exposed, may occur. These deposits may be removed by rubbing these areas with a soft rubber eraser.

TENTATIVE SPECIFICATIONS

FOR

SINGLE AND DOUBLE REFINED WROUGHT-IRON BARS[1]

A.S.T.M. Designation: A 189 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1936.

Scope

1. These specifications cover refined wrought-iron bars, as follows:

Grade A.—Double refined, round, hexagonal and rectangular bars.

Grade B.—Single refined, round, hexagonal and rectangular bars.

Manufacture

2. (*a*) The bars shall be made from pig puddled or processed wrought iron[2] and shall be free from any admixture of iron scrap or steel. All bars shall be of the full length of the pile.

Grade A.—The original muck bars shall be twice piled and rerolled.

Grade B.—The original muck bars shall be piled and rerolled.

(*b*) *Iron Scrap.*—Unless otherwise specified by the purchaser, the term "iron scrap," applies only to foreign or bought scrap and does not include local mill products which are free from foreign or bought scrap. Any local mill products used shall be the equal of the material specified.

Chemical Composition

3. The iron shall conform to the following requirements as to chemical composition:

Manganese, max., per cent.. 0.06

Check Analyses

4. (*a*) An analysis may be made by the purchaser from a broken tension test specimen representing each lot as specified in Section 9 (*a*). The chemical composition thus determined shall conform to the requirement specified in Section 3.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee A-2 on Wrought Iron.

[2] Wrought iron is defined as follows in the Standard Definitions of Terms Relating to Wrought Iron Specifications (A.S.T.M. Designation: A 81) of the American Society for Testing Materials:

Wrought Iron.—**A ferrous material, aggregated from a solidifying mass of pasty particles of highly refined metallic iron with which, without subsequent fusion, is incorporated a minutely and uniformly distributed quantity of slag.**

(*b*) Drillings for analysis shall be so taken as to represent the entire cross-section of the specimen.

Tension Tests

5. (*a*) The iron shall conform to the following requirements as to tensile properties:

	Round, Square and Hexagonal Bars under $1\frac{5}{8}$ in. in Diameter or Thickness	Round, Square and Hexagonal Bars over $1\frac{5}{8}$ in. and up to but not including $2\frac{1}{2}$ in. in Diameter or Thickness	Round, Square and Hexagonal Bars $2\frac{1}{2}$ in. and over in Diameter or Thickness, and all Flat Bars
GRADE A—DOUBLE REFINED			
Tensile strength, lb. per sq. in.	48 000 to 54 000	47 000 to 54 000	46 000 to 54 000
Yield point, min., lb. per sq. in.	0.6 tens. str	0.55 tens. str.	0.50 tens. str.
Elongation in 8 in., min., per cent	28[a]	25	22
Reduction of area, min., per cent	45	40	35
GRADE B—SINGLE REFINED			
Tensile strength, min., lb. per sq. in.	48 000	47 000	46 000
Yield point, min., lb. per sq. in.	0.6 tens. str.	0.55 tens. str.	0.50 tens. str.
Elongation in 8 in., min., per cent	25	22	20
Reduction of area, min., per cent	40	35	30

[a] Bars not exceeding $\frac{5}{8}$ in. in diameter or thickness will be accepted if the elongation in 8 in. is not less than 25 per cent.

(*b*) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine. The speed of the crosshead of the machine shall not exceed $\frac{3}{4}$ in. per min. After passing the yield point, the speed of the crosshead shall not exceed 3 in. per min.

Bend Tests

6. (*a*) *Cold Bend Tests.*—The test specimen shall stand being bent cold through 180 deg. around a pin the diameter of which is equal to the diameter or thickness of the specimen, without fracture on the outside of the bent portion.

(*b*) *Hot Bend Tests.*—The test specimen when heated to a temperature between 1700 and 1800 F. (925 and 980 C.), shall stand being bent through 180 deg. flat on itself, without fracture on the outside of the bent portion.

(*c*) *Nick Bend Tests.*—The test specimen, when nicked 25 per cent around with a tool having a 60-deg. cutting edge to a depth of not less than 8 nor more than 16 per cent of the diameter or thickness of the specimen and broken slowly, shall show a wholly fibrous fracture.

(*d*) Bend tests may be made by pressure or by blows.

Step Test

7. In the case of Grade A bars only, the test specimen when reduced to 50 per cent of its original diameter by smooth-turned steps, each 2 in. in length and $\frac{1}{8}$ in. less in diameter than the preceding, shall indicate freedom from injurious seams, laminations and other internal defects.

Etch Test

8. The cross section of the test specimen shall be ground or polished and etched[1] for a sufficient period to develop the structure. This test shall show the material to be uniform and free from steel.

Test Specimens

9. (*a*) *Tension Test Specimens.*—Tension test specimens shall be the full section of material as rolled, if possible, otherwise, the specimens shall be taken from the material as rolled. For bars 2½ in. or less in diameter or thickness, the axis of the tension specimen shall coincide with the axis of the bar. For bars over 2½ in. in diameter or thickness, the axis of the tension specimen shall be located at any point one-half the distance from the center to the surface and shall be parallel to the axis of the bar; and the specimen shall be turned to the diameter of 1 in. for a length of at least 9 in. with enlarged ends.

(*b*) *Bend Test Specimens.*—Round, square and hexagonal bars not over 1½ in. in diameter or thickness, and flat bars not over 1 in. in thickness or 2 in. in width shall be bent in full section as rolled. For larger round, square and hexagonal bars the bend specimen may be reduced to 1½ in. in diameter. For flat bars the bend specimen may be reduced to a width not less than their thickness. The edges of the machined specimens shall be rounded to a radius of $\frac{1}{16}$ in.

Number of Tests

10. (*a*) Bars of each size shall be sorted into lots of 100 each. Two bars shall be selected at random from each lot or fraction thereof, and tested as specified in Sections 4, 5, 6 and 7; but only one of these bars shall be tested as specified in Section 8.

(*b*) If any of the specimens originally selected to represent a lot of material contain surface defects not visible before testing but visible after testing, or if a tension test specimen fails to meet the physical requirements of Section 5 and breaks outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, the individual specimen shall be rejected and one retest from a different bar will be allowed.

Permissible Variations in Size

11. (*a*) Round, square and hexagonal bars shall not vary more than the limits given in the following table:

NOMINAL SIZE OF ROUND, SQUARE AND HEXAGONAL BARS	PERMISSIBLE VARIATIONS IN SIZE, IN.	
	UNDER	OVER
Up to ½ in., incl	0.007	0.007
Over ½ in. up to 1 in., incl	0.10	0.10
Over 1 in. up to 2 in., incl	$\frac{1}{64}$	$\frac{1}{32}$
Over 2 in. up to 3 in., incl	$\frac{1}{32}$	$\frac{3}{64}$
Over 3 in. up to 5 in., incl	$\frac{1}{32}$	$\frac{3}{32}$
Over 5 in. up to 8 in., incl	$\frac{1}{16}$	$\frac{1}{8}$

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[1] A solution of 10 per cent hydrochloric acid (sp. gr. 1.19), 30 per cent sulfuric acid (sp. gr. 1.89), and 60 per cent water; or 25 per cent nitric acid (sp. gr. 1.42) and 75 per cent water, is recommended for the etch test.

(*b*) The width or thickness of flat bars shall not vary more than 2 per cent from that specified.

Finish

12. The bars shall be smoothly rolled and free from slivers, depressions, seams, crop ends and evidences of being burnt.

Marking

13. The bars shall be stamped or marked as designated by the purchaser.

Inspection

14. (*a*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified.

(*b*) The purchaser may make the tests to govern the acceptance or rejection of material in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

Rejection

15. (*a*) If either of the test bars selected to represent a lot does not conform to the requirements specified, the lot will be rejected.

(*b*) Bars which develop defects in forging or machining will be rejected, and the manufacturer shall be notified.

Rehearing

16. Samples tested in accordance with Section 14 (*b*), which represent rejected material shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS

FOR

WROUGHT-IRON PLATES[1]

A.S.T.M. Designation: A 42 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ADOPTED, 1913; REVISED, 1918, 1930; REISSUED AS TENTATIVE, 1934;
REVISED, 1935, 1936.[2]

Scope

1. These specifications cover standard and special forming wrought-iron[3] plates for general fabrication purposes, including bending and flanging, in thicknesses $\frac{3}{16}$ in. and over.

Manufacture

2. (*a*) All plates shall be rolled from blooms, piles or slabs which are entirely free from any admixture of iron scrap (Note) or steel.

(*b*) Piles for plates shall be made from wrought iron.[2] The constituent bars shall be the full length of the pile.

NOTE.—The term iron scrap applies only to foreign or bought scrap and does not include local mill products which are free from foreign or bought scrap. Any local mill products used shall be the equal or of a higher grade than the material specified.

Chemical Composition

3. The iron shall conform to the following requirement as to chemical composition:

Manganese, max., per cent.................................... 0.06

Tension Tests

4. (*a*) *Standard Plate.*—Standard plate shall conform to the following minimum requirements as to tensile properties. These

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee A-2 on Wrought Iron.

These tentative specifications are in effect a tentative revision of, and replace the former Standard Specifications for Wrought-Iron Plates (A.S.T.M. Designation: A 42 - 30), which standard was accordingly discontinued in 1936.

[2] Latest revision accepted by Committee E-10 on Standards, August 26, 1936.

[3] Wrought iron is defined as follows in the Standard Definitions of Terms Relating to Wrought Iron Specifications (A.S.T.M. Designation: A 81) of the American Society for Testing Materials:

Wrought Iron.—A ferrous material, aggregated from a solidifying mass of pasty particles of highly refined metallic iron with which, without subsequent fusion, is incorporated a minutely and uniformly distributed quantity of slag.

requirements apply only to longitudinal test specimens; no transverse tests shall be made.

Tensile strength, lb. per sq. in.	48 000
Yield point, lb. per sq. in.	27 000
Elongation in 8 in., per cent	14

(*b*) *Special Forming Plate.*—With special forming plate, the longitudinal strength and ductility are directly related to the transverse properties, and are scaled downward in ratio to the increase in transverse properties, according to the following formulas:

Tensile strength, lb. per sq. in. = 51,000 − (1500 × transverse ductility of plate (expressed as percentage elongation in 8 in.)

Longitudinal elongation in 8 in., per cent = 16 − transverse ductility (expressed as percentage elongation in 8 in.)

Yield point, lb. per sq. in. 27,000

(*c*) The purchaser shall specify in the order the minimum transverse ductility desired in conformity with the fabrication requirements. When no transverse ductility is specified in the order, standard plate will be supplied.

(*d*) Representative requirements for special forming plate, in accordance with the formulas, are as follows:

TRANSVERSE DUCTILITY (ELONGATION IN 8 IN.), PER CENT		MINIMUM LONGITUDINAL PROPERTIES	
		TENSILE STRENGTH,[a] MIN., LB. PER SQ. IN.	ELONGATION[b] IN 8 IN., MIN., PER CENT
3	51,000 − (1500 × 3) =	46 500	(16 − 3) = 13
4		45 000	12
5		43 500	11
6		42 000	10
7		40 500	9
8		39 000	8

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[a] See Section 5 (*a*).
[b] See Section 5 (*b*).

(*e*) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine. The speed of the crosshead of the machine shall not exceed $\frac{3}{4}$ in. per minute.

Modifications in Elongation

5. (*a*) For plates over $\frac{3}{4}$ in. in thickness, a reduction of 1000 lb. per sq. in. from the indicated tensile strength will be allowed for each increase of $\frac{1}{8}$ in. in thickness over $\frac{3}{4}$ in., with a proportional reduction for fractional parts of $\frac{1}{8}$ in.; but in no case shall the tensile strength be less than 39,000 lb. per sq. in.

(*b*) For plates under $\frac{7}{16}$ in. in thickness, a deduction of 1 per cent from the percentages of elongation specified in Section 4 shall be made for each decrease of $\frac{1}{16}$ in. in thickness below $\frac{7}{16}$ in.; but in no case shall the elongation be less than 8 per cent.

Bend Tests

6. (*a*) *Cold-bend Tests.*—The test specimen shall stand being bent cold through 90 deg., without fracture on the outside of the bent portion, around a pin the diameter of which is:

$$d = \frac{40 \times \text{thickness of plate}}{\text{specified longitudinal elongation in 8 in., per cent}}$$

(*b*) *Nick-bend Tests.*—The test specimen, when nicked on one side and slowly broken, shall show a wholly fibrous fracture.

Test Specimens

7. (*a*) Tension and bend test specimens shall be taken from the finished plate and except as specified in Paragraph (*b*) shall be of the full thickness of the plate as rolled.

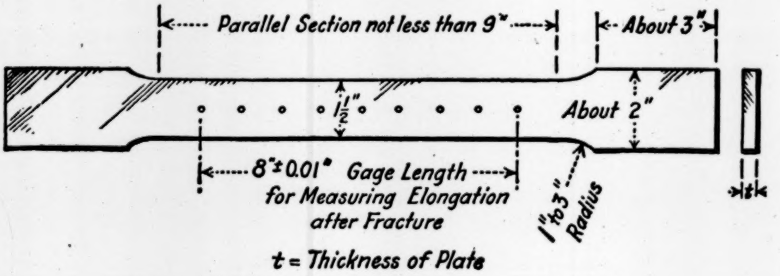
Parallel Section not less than 9"
About 3"
1½"
About 2"
8"±0.01" Gage Length for Measuring Elongation after Fracture
1" to 3" Radius
t
t = Thickness of Plate

FIG. 1.—Standard 8-in. Gage Length Test Specimen.

(*b*) Test specimens may be machined to the form and dimensions shown in Fig. 1, or with both edges parallel. When plates are $1\frac{1}{2}$ in. or over in thickness, the specimens may be machined to a thickness of not less than $\frac{3}{4}$ in. or, if desired, to a diameter of not less than $\frac{3}{4}$ in. for a distance of not less than 9 in.

(*c*) The machined edges of rectangular bend test specimens may be rounded to a radius of not over $\frac{1}{16}$ in.

Number of Tests

8. (*a*) One tension, one cold-bend and one nick-bend test shall be made for each $\frac{1}{8}$-in. variation in plate thickness and not less than one test for every ten plates as rolled. Where modification of the usual transverse properties is specified, and the tensile properties are determined by the formulas in Section 4 (*a*), two tension test specimens shall be taken at right angles to each other, one parallel to the longitudinal axis and the other parallel to the transverse axis.

TABLE I.—PERMISSIBLE VARIATIONS OF RECTANGULAR PLATES ORDERED TO WEIGHT.

Ordered Weight, lb. per sq. ft.	Permissible Variations in Average Weights per Square Foot of Plates for Widths Given, Expressed in Percentages of Ordered Weights																		Ordered Weight, lb. per sq. ft.
	Under 48 in.		48 to 60 in., excl.		60 to 72 in., excl.		72 to 84 in., excl.		84 to 96 in., excl.		96 to 108 in., excl.		108 to 120 in., excl.		120 to 132 in., excl.		132 in. or over		
	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	
Under 5	5	3	5.5	3	6	3	7	3	...	...	...	...	...	...	...	...	...	...	Under 5
5 to 7.5 excl.	4.5	3	5	3	5.5	3	6	3	...	...	...	...	...	...	...	...	...	...	5 to 7.5 excl.
7.5 " 10 "	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	...	...	...	...	7.5 " 10 "
10 " 12.5 "	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	9	3	10 " 12.5
12.5 " 15 "	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	12.5 " 15
15 " 17.5 "	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	15 " 17.5 "
17.5 " 20 "	2.5	2	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	17.5 " 20 "
20 " 25 "	2	2	2.5	2	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	20 " 25 "
25 " 30 "	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	4.5	3	5	3	25 " 30
30 40 "	2	2	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	4.5	3	30 " 40 "
40 or over	2	2	2	2	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	40 or over

NOTE.—The weight per square foot of individual plates shall not vary from the ordered weight by more than one and one-third the amount given in this table.

TABLE II.—PERMISSIBLE OVERWEIGHTS OF RECTANGULAR PLATES ORDERED TO THICKNESS.

Ordered Thickness, in.	Permissible Excess in Average Weights per Square Foot of Plates for Widths Given, Expressed in Percentages of Nominal Weights									Ordered Thickness, in.
	Under 48 in.	48 to 60 in., excl.	60 to 72 in., excl.	72 to 84 in., excl.	84 to 96 in., excl.	96 to 108 in., excl.	108 to 120 in., excl.	120 to 132 in., excl.	132 in. or over	
Under $\frac{1}{8}$	9	10	12	14	....	....	..	..	..	Under $\frac{1}{8}$
$\frac{1}{8}$ to $\frac{3}{16}$ excl.	8	9	10	12	....	....	..	..	..	$\frac{1}{8}$ to $\frac{3}{16}$ excl.
$\frac{3}{16}$ " $\frac{1}{4}$ "	7	8	9	10	12	....	..	..	..	$\frac{3}{16}$ " $\frac{1}{4}$ "
$\frac{1}{4}$ " $\frac{5}{16}$ "	6	7	8	9	10	12	14	16	19	$\frac{1}{4}$ " $\frac{5}{16}$ "
$\frac{5}{16}$ " $\frac{3}{8}$ "	5	6	7	8	9	10	12	14	17	$\frac{5}{16}$ " $\frac{3}{8}$ "
$\frac{3}{8}$ " $\frac{7}{16}$ "	4.5	5	6	7	8	9	10	12	15	$\frac{3}{8}$ " $\frac{7}{16}$ "
$\frac{7}{16}$ " $\frac{1}{2}$ "	4	4.5	5	6	7	8	9	10	13	$\frac{7}{16}$ " $\frac{1}{2}$ "
$\frac{1}{2}$ " $\frac{5}{8}$ "	3.5	4	4.5	5	6	7	8	9	11	$\frac{1}{2}$ " $\frac{5}{8}$ "
$\frac{5}{8}$ " $\frac{3}{4}$ "	3	3.5	4	4.5	5	6	7	8	9	$\frac{5}{8}$ " $\frac{3}{4}$ "
$\frac{3}{4}$ " 1 "	2.5	3	3.5	4	4.5	5	6	7	8	$\frac{3}{4}$ " 1 "
1 or over	2.5	2.5	3	3.5	4	4.5	5	6	7	1 or over

NOTE.—The weight of individual plates ordered to thickness shall not exceed the nominal weight by more than one and one-third the amount given in this table.

(*b*) If any of the specimens originally selected to represent a lot of material contains surface defects not visible before testing but visible after testing, or if a tension test specimen fails to meet the physical requirements of Section 4 and breaks outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, the individual specimen shall be rejected and one retest from a different plate will be allowed. If the retest also fails, the plates represented by such test will be rejected.

Other Tests

9. Where desired, the purchaser may, at his own expense, subject the material to chemical, microscopic, or other tests to determine its quality in conformity with the intent of these specifications.

Variations in Weight and Thickness

10. The weight or thickness of plates shall be covered by the following permissible variations. One cubic inch of wrought iron is assumed to weigh 0.2776 lb.

(*a*) *Plates, When Ordered to Weight per Square Foot.*—The weight of each lot[1] of plates in each shipment shall not vary from the weight ordered more than the amounts given in Table I.

(*b*) *Plates, When Ordered to Thickness.*—The thickness of each plate shall not vary more than 0.01 in. under that ordered.

The overweight in each lot[1] of plates in each shipment shall not exceed the amounts given in Table II.

Finish

11. The plates shall be straight, smooth and free from cinder spots and holes, injurious flaws, buckles, blisters, seams and laminations.

Marking

12. The plates shall be stamped or otherwise marked as designated by the purchaser.

Inspection

13. (*a*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the plates ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to

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[1] The term "lot" as applied to Table I means all the plates of each group width and group weight. As applied to Table II, it means all the plates of each group width and group thickness.

satisfy him that the plates are being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

(*b*) The purchaser may make the tests to govern the acceptance or rejection of plates at his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

Rejection

14. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 13 (*b*) shall be reported within five working days from the receipt of samples.

(*b*) Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing

15. Samples tested in accordance with Section 13 (*b*), which represent rejected plates, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS
FOR
WROUGHT-IRON RIVETS AND RIVET ROUNDS[1]

A.S.T.M. Designation: A 152 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1933; REVISED, 1935, 1936.

A. Requirements for Rolled Bars

MANUFACTURE

Process

1. The rivet bars shall be made from wrought iron[2] which shall be free from any admixture of iron scrap or steel.

NOTE.—The term "iron scrap" applies only to foreign or bought scrap and does not include local mill products which are free from foreign or bought scrap. Any local mill products used shall be the equal or of a higher grade than the material specified.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition

2. The wrought iron shall conform to the following requirement as to chemical composition:

Manganese, max., per cent	0.06

Check Analyses

3. (*a*) Analyses may be made by the purchaser from a broken test specimen representing each lot, as specified in Section 7 (*a*). At the discretion of the purchaser, the chemical analysis may be made from a rivet. Each rivet so tested shall not represent more than 2000 lb. of any one size.

(*b*) Drillings for analysis shall be so taken as to represent the entire cross-section of the specimen.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee A-2 on Wrought Iron.

[2] Wrought iron is defined as follows in the Standard Definitions of Terms Relating to Wrought Iron Specifications (A.S.T.M. Designation: A 81) of the American Society for Testing Materials:

Wrought Iron.—A ferrous material, aggregated from a solidifying mass of pasty particles of highly refined metallic iron, with which, without subsequent fusion, is incorporated a minutely and uniformly distributed quantity of slag.

PHYSICAL PROPERTIES AND TESTS

Tension Tests

4. (*a*) The wrought iron shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb. per sq. in.		47 000
Yield point, lb. per sq. in.		0.6 tens. str.
Elongation in 8 in., per cent	rounds $\frac{1}{4}$ to $\frac{7}{16}$ in., incl., in diam.	22
	rounds $\frac{7}{16}$ to $\frac{3}{4}$ in., incl., in diam.	24
	rounds over $\frac{3}{4}$ to 2 in., incl., in diam.	28

(*b*) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine.

Bend Tests

5. (*a*) *Quenched, Cold-bend Tests.*—A test specimen shall be heated between 1600 and 1700 F. (870 and 925 C.), and quenched in cold water, after which it shall stand being bent cold through 90 deg. on a radius which is equal to the diameter of the specimen without fracture on the outside of the bent portion.

(*b*) *Nick-bend Tests.*—A test specimen, when nicked 25 per cent around the circumference with a tool having a 60-deg. cutting edge, to a depth of not less than 8 nor more than 16 per cent of the diameter or thickness of the specimen, and broken slowly, shall show a wholly fibrous fracture.

(*c*) *Hot-bend Tests.*—A test specimen, when heated to a temperature between 1700 and 1800 F. (925 and 980 C.), shall stand being bent through 180 deg. flat on itself without fracture on the outside of the bent portion.

(*d*) Bend tests may be made by pressure or blows.

Test Specimens

6. All test specimens shall be of the full section of the material as rolled.

Number of Tests

7. (*a*) All bars of a given size shall be piled separately, sorted in lots of 100 each. Two bars shall be selected at random from each lot or fraction thereof and tested as specified in Sections 4 to 6.t

(*b*) If any of the specimens originally selected to reprenes a lot of material contains surface defects not visible before testing but visible after testing, or if a tension test specimen fails to meet the physical test requirements of Section 4 and breaks outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, the individual specimen shall be rejected and one retest from a different bar will be allowed.

Micrographic Examination

8. In case of doubt as to the presence of steel, the purchaser may, at his own expense, make micrographic examination to assist in determining whether the material conforms to the requirements of Section 1.

Permissible Variations

9. The diameter of rivet bars shall not vary from that specified by more than the amount given in the following table:

Diameter, in.	Permissible Variations in Diameter, in.	Out of Round, in.
Up to ½, inclusive	±0.007	0.010
Over ½ to 1, inclusive	±0.010	0.013
Over 1 to 1¼, inclusive	±0.012	0.016
Over 1¼ to 1½, inclusive	±0.015	0.021
Over 1½ to 2, inclusive	±0.022	0.023

Finish

10. The bars shall be smoothly rolled and shall be free from slivers, depressions, crop ends and seams, and shall show no evidence of being burnt.

Inspection and Rejection

Inspection

11. (*a*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the bars are being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment.

(*b*) The purchaser may make the tests to govern the acceptance or rejection of material in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

(*c*) All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection

12. (*a*) All bars of one size in any one lot will be rejected if the test specimens representing that size and lot do not conform to the requirements specified.

(*b*) Unless otherwise specified, any rejection based on tests made in accordance with Section 11 (*b*) shall be reported within five working days from the receipt of samples.

Rehearing

13. Samples tested in accordance with Section 11 (*b*), which represent rejected material, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

B. Requirements for Finished Rivets

Material

14. The material used in the manufacture of the rivets shall conform to the requirements for rolled bars as specified in Sections 1 to 13, inclusive.

PHYSICAL PROPERTIES AND TESTS

Flattening Test

15. The rivet head shall stand being flattened, while hot, to a diameter two times the diameter of the shank, as shown in Fig. 1, without cracking at the edges.

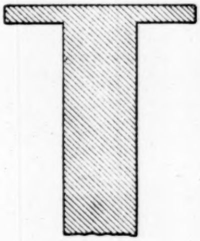

FIG. 1.—Flattening Test.

Etch Test

16. The rivet shall be split longitudinally through head and shank. After grinding or polishing and etching in acid,[1] the section shall show freedom of folds at base of head, and the fiber lines shall show symmetrical displacement. (See Fig. 2).

Number of Tests

17. Three flattening and three etch tests shall be made from each lot of 2000 lb. or less of any one diameter of rivets offered for inspection, each of which shall conform to the requirements specified in Sections 15 and 16.

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[1] A solution of 10 per cent hydrochloric acid (sp. gr. 1.19), 30 per cent sulfuric acid (sp. gr. 1.84), and 60 per cent water; or 25 per cent nitric acid (sp. gr. 1.42) and 75 per cent water, is recommended for the etch test.

WORKMANSHIP AND FINISH

Workmanship and Finish

18. The rivets shall be true to form and concentric, shall be made in a workmanlike manner, and shall be free from injurious defects. The heads shall not show cracks or splits on the edge but may contain a slight flash.

INSPECTION AND REJECTION

Inspection

19. The inspector representing the purchaser shall have free entry, at all times while the work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the rivets ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the rivets are being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture of the rivets prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

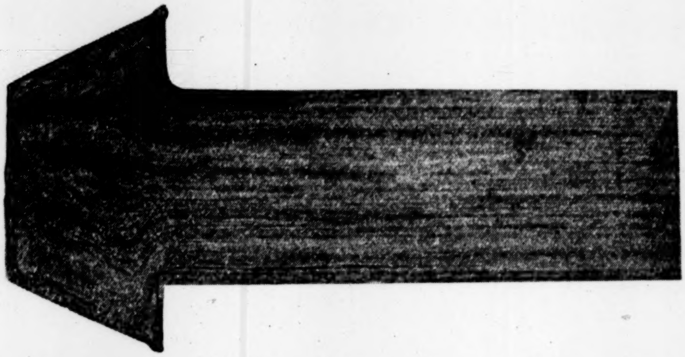

FIG. 2.—Showing Symmetrical Displacement of Fiber Lines After Etching Test.

Rejection

20. Rivets which show defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

TENTATIVE SPECIFICATIONS
FOR
LIGHTWEIGHT AND THIN-SECTIONED GRAY-IRON CASTINGS[1]

A.S.T.M. Designation: A 190 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1936.

Scope

1. These specifications cover lightweight and thin-sectioned gray-iron castings in which appearance, machinability, and dimension tolerances are primary considerations. It is the purpose of these specifications to establish a standard of quality for lightweight and thin-sectioned gray-iron castings based on the visual inspection of sample castings and testing of representative locations on sample castings for machinability. Strength is not a primary consideration, but may be specified in accordance with the Standard Specifications for Gray-Iron Castings (A.S.T.M. Designation: A 48) of the American Society for Testing Materials,[2] using only the 0.875-in. diameter test bar. The strength class shall be designated.

NOTE.—Strength tests should not be specified unless absolutely required, because as the strength requirements are increased the making of the casting becomes more difficult as does also the machining of the casting, with the result that costs are increased.

Sample Castings

2. One or more sample castings, from each pattern shall be submitted to the purchaser by the manufacturer for the purpose of establishing standards of appearance, machinability, and dimension tolerances. These castings shall be made to conform to the dimensions and appearance required by the purchaser and shall be preserved by the manufacturer as standards of quality as long as the requirements of the purchaser remain unchanged.

Physical Tests

3. Physical tests, when required, shall be made in accordance with the Standard Specifications for Gray-Iron Castings (A.S.T.M. Designation: A 48) of the American Society for Testing Materials.[2]

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee A-3 on Cast Iron.

[2] 1936 Book of A.S.T.M. Standards, Part I, p. 457.

Hardness Tests

4. Hardness test requirements at some designated spot on the casting may be prescribed under these specifications by agreement between the purchaser and the manufacturer.

Machinability

5. All castings shall be machinable at the locations so designated by the purchaser at cutting speed or by tests agreed upon between the purchaser and the manufacturer.

NOTE.—There is no definite factor for correlation between physical tests and machinability.

Chemical Composition

6. (*a*) It is not the intent of these specifications to consider chemical compositions.

(*b*) By agreement between the manufacturer and purchaser, the quantities of any alloying elements may be specified.

Workmanship and Finish

7. The castings shall be free from cracks, gas holes, flaws and excessive shrinkage. Surfaces of the castings shall be free from burnt-on sand and shall have the same degree of smoothness as the sample castings. Runners, risers, fins, and other cast-on pieces shall be removed, unless otherwise agreed upon by the purchaser and the manufacturer.

Inspection and Rejection

8. (*a*) Inspection shall be by visual inspection for appearance and surface smoothness in comparison with samples accepted as standard. Failure to meet the requirements of these specifications as to appearance and smoothness shall be sufficient cause for rejection as defective castings.

(*b*) Inspection as to machinability or dimension tolerances shall be based on standards agreed upon and failure to meet such standard shall be sufficient cause for rejection as defective castings.

(*c*) Where alloying elements are agreed upon, the purchaser may make check analysis from any casting or lot of castings delivered under these specifications, and failure to meet the composition requirement shall be sufficient cause for rejection as defective castings.

(*d*) Failure to meet the requirements of these specifications as to physical tests, when required, shall be sufficient cause for rejection as defective castings.

Certification

9. Upon request of the purchaser, the manufacturer shall be prepared to certify that his product conforms to any strength specifications or alloy analysis covered by these specifications.

TENTATIVE SPECIFICATIONS
FOR
CUPOLA MALLEABLE IRON[1]

A.S.T.M. Designation: A 197 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1936.[2]

Scope

1. These specifications cover malleable iron for castings made by the cupola process.

Certification

2. The manufacturer shall be prepared to certify, upon request of the purchaser, that the material conforms to the requirements of these specifications.

Process

3. The iron shall be made by the cupola process.

Manufacture Control and Records

4. The iron shall be produced under constant control of chemical composition and physical properties. Records of the chemical composition of the iron and of the physical properties of the test specimens shall be systematically made and maintained.

Primary Graphite

5. Castings shall be free from primary graphite.

Tension Tests

6. (*a*) The tension test specimen specified in Section 7 shall conform to the following minimum requirements as to tensile properties:

Tensile strength, min., lb. per sq. in.	40 000
Yield point, min., lb. per sq. in.	30 000
Elongation in 2 in., min., per cent	5.0

(*b*) The yield point may be determined by the drop of the beam or halt in the gage of the testing machine, or by the dividers method. When a strainometer is used in place of dividers a deformation of 0.01 in. over a gage length of 2 in. shall be regarded as indicating the yield point.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee A-7 on Malleable Iron Castings.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 26, 1936.

Test Specimens

7. (*a*) Tension test specimens shall be of the form and dimensions shown in Fig. 1. Specimens whose mean diameter at the smallest section is less than $\frac{19}{32}$ in. shall be discarded.

(*b*) Two tension test specimens shall be cast from each four hours of the run or fraction thereof. Patterns for tension test specimens shall have adequate risers to secure sound bars. Specimens shall be suitably marked for identification as to date, cupola, and approximate hour of pouring. Test specimens shall be annealed with castings.

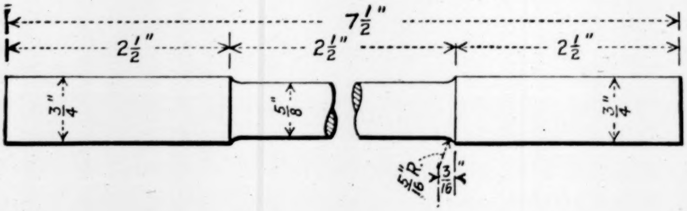

FIG. 1.—Tension Test Specimen.

Workmanship and Finish

8. The castings shall conform substantially to the patterns and shall be sound, clean, free from sand and of workmanlike finish.

Marking

9. The castings shall be marked with the manufacturer's name or trade-mark. For steam service pressures in excess of 150 lb. per sq. in., the castings shall be marked with the manufacturer's name or trade-mark, numerals to indicate the steam service intended, and any other marks which will clearly indicate the maximum service for which the casting is intended.

TENTATIVE DEFINITIONS OF TERMS RELATING TO CAST IRON[1]

A.S.T.M. Designation: A 196 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1936.[2]

Cast Iron.—Iron containing so much carbon that, as cast, it is not usefully malleable at any temperature. It usually contains from 1.7 to 4.5 per cent carbon and in most cases an important percentage of silicon.

NOTE.—On solidifying from the molten state, iron containing less than about 1.7 per cent of carbon forms a solid, termed austenite, which contains all the carbon that was present in the liquid. This limit at 1.7 per cent carbon is affected by other elements such as silicon so that in the presence of 2 per cent silicon the limit of solubility is 1.5 per cent carbon. If the iron contains more than about 1.7 per cent of carbon, a residual liquid, or eutectic, is left which contains about 4 per cent of carbon, and which solidifies at about 2100 F. (1150 C.). The formation of this eutectic ledeburite is the essential difference between cast iron and steel.

Pig Iron.—Cast iron usually produced by smelting iron ores in the blast furnace. It may have been cast into pigs or held in a molten condition for charging into a steel-making furnace.

Gray Iron.—Cast iron having a gray fracture as cast. In general, it is readily machinable with ordinary tools. The combined carbon usually does not exceed 0.8 per cent, and may be much lower.

NOTE.—The carbon in gray iron is largely present as flakes of graphite in a matrix of pearlite and ferrite. The matrix may be changed by heat treatment or the use of alloying elements.

White Iron.—Cast iron having a white fracture. It is very hard and difficult to machine. The carbon is practically all in the form of iron carbide.

Mottled Iron.—Cast iron having a mottled fracture. The structure and fracture show a mixture of gray iron and white iron.

Malleable Cast Iron.—Iron, white as cast, which has been made malleable by a heat treatment which has converted substantially all of the combined carbon into nodules of graphite.

Pearlitic Malleable Cast Iron.—Iron, white as cast, which has been made malleable by a heat treatment which has converted some of the combined carbon into graphite, leaving, however, significant amounts of combined carbon in the product.

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[1] Under the standardization procedure of the Society, these definitions are under the jurisdiction of the A.S.T.M. Committee A-3 on Cast Iron.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 26, 1936.

SEMISTEEL.—A vague trade name for various cast-iron products made by adding steel to the melting charge. The term never had a definite meaning and should now be considered obsolete.

HIGH-TEST CAST IRON.—A term sometimes used to designate gray cast iron having a tensile strength substantially greater than that of ordinary cast iron. This term should now be considered obsolete, since the Standard Specifications for Gray-Iron Castings (A.S.T.M. Designation: A 48)[1] definitely classifies gray-iron castings according to strength.

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[1] 1936 Book of A.S.T.M. Standards, Part I, p. 457.

TENTATIVE SPECIFICATIONS

FOR

ALUMINUM-BASE ALLOY PERMANENT MOLD CASTINGS[1]

A.S.T.M. Designation: B 108 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1936.[2]

By publication of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing the specifications against liability for infringement of Letters Patent nor assume any such liability, and such publication should not be construed as a recommendation of any patented or proprietary application that may be involved.

Scope

1. These specifications cover aluminum-base alloy permanent mold castings having a specific gravity of 3 or less. Eleven types of alloys are specified and are designated Alloys 1 to 11, inclusive. (See Table of Supplementary Data in the Appendix.)

2. These specifications refer to castings of two classes: namely,
   Standard commercial quality for regular applications, and
   Class A alloys where the greatest freedom from impurities is required for special applications.

Manufacture

3. The finished castings shall be uniform in composition and free from blow holes, cracks, shrinks, and other injurious defects.

Chemical Composition

4. The alloys shall conform to the chemical composition requirements specified in Table I.

Sampling for Chemical Analysis

5. (*a*) The samples for chemical analyses shall be selected as far as possible by heats or melts, unless otherwise mutually agreed upon by the manufacturer and the purchaser.

(*b*) The sample for determining the chemical composition shall be taken by sawing, drilling or milling the casting or test specimen in such a manner as to be representative of the material on test.

(*c*) The saw, drill, cutter, or other tool used for sampling the casting shall be thoroughly cleaned. No lubricant shall be used in the operation, and the sawings or metal chips shall be carefully treated with a magnet to remove any particles of iron introduced in taking the sample.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-7 on Light Metals and Alloys, Cast and Wrought.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 26, 1936.

Method of Chemical Analysis

6. The chemical analysis shall be made in accordance with the Tentative Methods of Chemical Analysis of Aluminum and Light Aluminum Alloys (A.S.T.M. Designation: B 40 – 36 T) of the American Society for Testing Materials,[1] or by any other method which has the precision shown in Table II.

Physical Properties

7. The physical properties as determined from test specimens shall conform to the requirements specified in Table III except as noted.

TABLE I.—CHEMICAL COMPOSITIONS OF ALUMINUM-BASE ALLOY PERMANENT MOLD CASTINGS.

NOTE 1.—Where single limits are shown these indicate the maximum amount permitted.

NOTE 2.—Analysis shall regularly be made only for the elements specifically mentioned in this table. If, however, the presence of other elements is indicated in the course of routine analysis, further analysis shall be made to determine that the total of these other elements is not present in excess of limits specified in the last column of the table.

NOTE 3.—The following applies to all specified limits in this table: For purposes of acceptance and rejection, an observed value or a calculated value obtained from analysis should be rounded off to the nearest unit in the last right-hand place of figures used in expressing the specified limit.

NOTE 4.—Titanium is permissible in Alloys 3, 4, 9, 9A and 10, but the maximum shall not exceed 0.2 per cent.

Alloy	Aluminum, per cent	Copper, per cent	Iron, per cent	Silicon, per cent	Magnesium, per cent	Nickel, per cent	Zinc, per cent	Manganese, per cent	Total Other Impurities, max., per cent
1............	remainder	4.5±0.5	1.0	2.5±0.5	0.2	....	0.2	0.3	0.3
1A............	remainder	4.5±0.5	1.0	2.5±0.5	0.05	....	0.2	0.3	0.3
2............	remainder	7.0±1.0	1.4	3.0±1.0	0.1	....	2.5	0.3	1.0[a]
3............	remainder	4.5±0.5	1.0	5.5±0.5	0.1	....	0.5	0.3	0.5
4............	remainder	10.0±0.75	1.5	1.0	0.25±0.10	0.3	0.4	0.3	0.3
5............	remainder	10.0±1.0	1.2	4.0±0.5	0.25±0.10	....	0.5	0.3	0.5
6............	remainder	1.0±0.5	1.3	12.0±1.0	1.0±0.25	2.5±0.5	0.1	0.05	0.2
7............	remainder	1.5±0.5	0.9	12.25±0.75	0.55±0.15	0.05	0.4	0.75±0.15	0.3
8............	remainder	0.3	0.8	11.0±1.0	0.05	....	0.3	0.5	0.5
9............	remainder	0.4	0.8	$5.0\left\{\begin{matrix}+1.0\\-0.5\end{matrix}\right.$	0.05	....	0.3	0.3	0.3
9A............	remainder	0.1	0.8	$5.0\left\{\begin{matrix}+1.0\\-0.5\end{matrix}\right.$	0.05	....	0.05	0.05	0.05 each
10............	remainder	0.2	0.5	7.0±0.5	0.3±0.1	....	0.05	0.05	0.05 each
11............	remainder	4.0±0.5	1.0	0.7	1.5±0.3	2.0±0.3	0.1	0.3	0.3

[a] Total of all elements other than aluminum not to exceed 14.5 per cent.

Test Specimens

8. (*a*) The test specimens shall be separately cast in a permanent mold. The specimens shall have a gage section diameter of 0.505 in. ± 0.010 in., and a gage length of not less than 2¼ in. The radius of fillet shall be not less than ½ in. A larger radius is not objectionable. The gage section diameter may be slightly reduced in the middle to promote breaking in this area.

(*b*) If the castings are to be heat treated, the test specimens representing such castings shall be heat treated with the castings they represent. They shall not be machined prior to test except to adapt the grip ends of the specimen to the jaws of the testing machine in such a manner as to assure axial loading.

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[1] A.S.T.M. Methods of Chemical Analyses of Metals, 1936.

Tension Tests

9. The tensile properties shall be determined in accordance with the Standard Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8) of the American Society for Testing Materials.[1]

Number of Tests

10. (*a*) The test specimens shall, so far as possible, be selected by heats or melts but, unless otherwise agreed upon by the purchaser or his representative and the manufacturer, two tension tests shall be made for each unit of 1000 lb. or fraction thereof, of clean castings.

(*b*) If any test specimen shows defective machining or flaws, it may be discarded; in which case the purchaser or his representative and the manufacturer shall agree upon the selection of another specimen in its stead.

TABLE II.—PRECISION REQUIREMENTS FOR METHODS OF CHEMICAL ANALYSIS EXPRESSED IN PERCENTAGE OF THE SPECIFIED VALUE.[a]

NOTE.—By "precision" is meant that the difference between the largest and the smallest value obtained in four repeat analyses shall not exceed twice the percentage stated in this table.

Alloy	Copper	Iron	Silicon	Magnesium	Manganese	Zinc	Titanium
1	2	5	5	10	10	10	..
1A	2	5	5	10	10	10	..
2	1	5	5	10	10	5	..
3	2	5	5	10	10	10	10
4	1	5	5	10	10	10	10
5	1	5	5	10	10	10	..
6	2	5	2	10	10	10	..
7	2	5	2	10	10	10	..
8	5	5	2	10	10	10	..
9	5	5	5	10	10	10	10
9A	10	5	5	10	10	10	10
10	5	5	2	10	10	10	10
11	2	5	10	5	10	10	..

[a] Where the amount of element present is expressed as a maximum, the precision is expressed in percentage of the maximum amount permitted.

Retests

11. If the results of the tension tests do not conform to the tensile properties specified in Section 7, the castings may be reheat-treated but not more than twice. The results of acceptable tests shall conform to the tensile property requirements as specified in Section 7.

Inspection

12. (*a*) Inspection may be made at the manufacturer's works where the castings are made, or at the point at which they are received, at the option of the purchaser.

(*b*) The general requirements specified in Section 3 shall be checked by visual inspection of the castings or by comparison with observational standards where such standards are established. It is advisable that observational standards representing acceptable material be set up which will govern when any question arises as to what defects are allowable under the best commercial practice.

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[1] 1936 Book of A.S.T.M. Standards, Part I, p. 833.

(*c*) If the purchaser elects to have inspection made at the manufacturer's works, the manufacturer shall afford the inspector representing the purchaser all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

TABLE III.—PHYSICAL PROPERTIES OF ALUMINUM-BASE ALLOY PERMANENT MOLD CASTINGS.

NOTE.—See Table of Supplementary Data in the Appendix.

ALLOY	CONDITION	TENSILE STRENGTH, MIN. LB. PER SQ. IN (TO THE NEAREST 1000 LB. PER SQ. IN.)	ELONGATION IN 2 IN., MIN. PER CENT (TO THE NEAREST 1 PER CENT)
1	Heat Treatment No. 1	33 000	4.5
	Heat Treatment No. 2	42 000	1[a]
1A	Heat Treatment No. 1	33 000	4.5
	Heat Treatment No. 2	42 000	1[a]
2	As-cast	23 000	....
3	As-cast	23 000	....
4	Heat Treatment No. 1	28 000	....
	Heat Treatment No. 2	38 000	....
5	As-cast	26 000	....
6	Heat Treatment No. 1	28 000	....
	Heat Treatment No. 2	36 000	....
7	Heat Treatment No. 1	32 000	....
	Heat Treatment No. 2	36 000	....
8	As-cast	27 000	3
9	As-cast	21 000	2
9A	As-cast	21 000	2.5
10	Heat Treatment No. 1	28 000	5
	Heat Treatment No. 2	30 000	3
11	Heat Treatment No. 1	33 000	....
	Heat Treatment No. 2	40 000	....

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[a] For information only.

Rejection

13. Castings which show injurious defects revealed by machining operations subsequent to acceptance may be rejected, and if rejected shall be replaced by the manufacturer without charge to the purchaser. The full weight of the original material rejected shall be returned to the manufacturer.

Rehearing

14. In the case of dissatisfaction regarding rejections based on chemical composition and tensile property requirements as specified in Sections 4 and 7, respectively, the manufacturer may make claim for a rehearing as a basis of arbitration within a reasonable time after receipt by the manufacturer of the rejection notification.

APPENDIX

The data in the following table are approximate and are supplied for general information only:

TABLE OF SUPPLEMENTARY DATA

Alloy	Approximate Specific Gravity	Corrosion Resistance	Casting Properties	Response to Heat Treatment	Principal Use	Machinability
1	2.76	Good	Good	Yes	General, where high strength and fair ductility are required	Good
1A	2.76	Good	Good	Yes	General, where high strength and high ductility are required.	Good
2	2.83	Fair	Good	Yes	General, automotive cylinder heads and washing machine agitators	Excellent
3	2.79	Fair	Excellent	No	General	Good
4	2.90	Fair	Good	Yes	Automotive pistons	Excellent
5	2.88	Fair	Good	Yes	General	Good
6	2.68	Good	Fair	Yes	Pistons	Fair
7	2.67	Good	Fair	Yes	Pistons	Fair
8	2.64	Excellent	Excellent	No	General thin sections	Poor
9	2.66	Good	Good	No	General and cooking utensils	Poor
9A	2.66	Excellent	Good	No	General with maximum corrosion resistance.	Poor
10	2.70	Excellent	Excellent	Yes	General where high strength and corrosion resistance are required	Good
11	2.78	Good	Fair	Yes	Aircraft and Diesel engine pistons	Good

TENTATIVE SPECIFICATIONS

FOR

ALUMINUM-BASE ALLOY SAND CASTINGS[1]

A.S.T.M. Designation: B 26 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED AS TENTATIVE, 1918; ADOPTED IN AMENDED FORM, 1921; REVISED, 1931; REISSUED AS TENTATIVE, 1933; REVISED, 1936.[2]

By publication of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing the specifications against liability for infringement of Letters Patent nor assume any such liability, and such publication should not be construed as a recommendation of any patented or proprietary application that may be involved.

Scope

1. These specifications cover aluminum-base alloy sand castings having a specific gravity of 3 or less. Twelve alloys are specified and are designated Alloys C, CC, F, G, GG, H, J, JJ, K, L, M, and N (see Explanatory Notes).

Manufacture

2. The finished casting shall be uniform in composition and as free from blow holes, cracks, shrinks, and other injurious defects as the best commercial practice will permit.

3. The responsibility of furnishing castings that can be laid out and machined to the finished dimensions within the specified tolerances as shown on the blueprints or drawings shall rest with the manufacturer, except where pattern equipment is furnished by the purchaser. Sufficient stock shall be allowed for shrinkage and, where required, for finishing; but castings of excessive size or weight shall not be furnished.

Chemical Composition

4. The alloys shall conform to the chemical composition requirements specified in Table I.

Sampling for Chemical Analysis

5. (*a*) Samples for chemical analyses shall be selected as far as possible by heats or melts, unless otherwise mutually agreed upon by the manufacturer and the purchaser.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-7 on Light Metals and Alloys, Cast and Wrought.

These specifications are in effect a revision of and replace the former Standard Specifications for Aluminum-Base Alloy Sand Castings (A.S.T.M. Designation: B 26 – 31), which standard was accordingly discontinued in 1933.

[2] Revision accepted by Committee E-10 on Standards, August 26, 1936.

(*b*) The sample for determining the chemical composition shall be taken by sawing, drilling or milling the casting or test specimen in such a manner as to be representative of the material on test.

(*c*) The saw, drill, cutter or other tool used for sampling the casting shall be thoroughly cleaned. No lubricant shall be used in the operation, and the sawings or metal chips shall be carefully treated with a magnet to remove any particles of iron introduced in taking the sample.

TABLE I.—CHEMICAL COMPOSITIONS OF ALUMINUM-BASE ALLOY SAND CASTINGS.

NOTE 1.—Where single limits are shown, these indicate the maximum amount permitted.

NOTE 2.—Analysis shall regularly be made only for the elements specifically mentioned in this table. If, however, the presence of other elements is indicated in the course of routine analysis, further analysis shall be made to determine that the total of these other elements is not present in excess of the limits specified in the last column of the table.

NOTE 3.—The following applies to all specified limits in this table: For purposes of acceptance and rejection, an observed value or a calculated value obtained from analysis should be rounded off to the nearest unit in the last right-hand place of figures used in expressing the specified limit.

Alloy	Aluminum, per cent	Copper, per cent	Iron, per cent	Silicon, per cent	Magnesium, per cent	Manganese, per cent	Zinc, per cent	Titanium, per cent	Nickel, per cent	Total Other Impurities, max., per cent
C.........	remainder	7.0±1.0	1.5	2.0±1.0	0.05	0.3	2.2	....	....	1.0[a]
CC.........	remainder	$7.7\left\{\begin{matrix}+0.8\\-0.7\end{matrix}\right.$	$1.0\left\{\begin{matrix}+0.4\\-0.2\end{matrix}\right.$	1.25±0.25	0.05	0.3	0.2	....	....	0.3
F..........	remainder	10.0±0.75	1.5	....	0.25±0.10	0.3	0.2	....	....	0.3[b]
G..........	remainder	4.5±0.5	1.0	1.2	0.03	0.05	0.05	0.2	....	0.05 each
GG.........	remainder	4.5±0.5	1.2	1.2	0.3	0.3	0.2	0.2	....	0.2
H..........	remainder	4.0±0.5	1.0	0.7	1.5±0.3	0.3	0.1	....	2.0±0.3	0.3
J..........	remainder	0.4	0.8	$5.0\left\{\begin{matrix}+1.0\\-0.5\end{matrix}\right.$	0.05	0.3	0.2	0.2	....	0.3
JJ..........	remainder	0.1	0.8	$5.0\left\{\begin{matrix}+1.0\\-0.5\end{matrix}\right.$	0.05	0.05	0.05	0.2	....	0.05 each
K..........	remainder	0.15	0.8	12.5±0.5	0.05	0.2	0.1	....	....	0.2
L..........	remainder	0.1	0.4	0.25	3.75±0.50	0.6	0.05	0.2	....	0.05 each
M..........	remainder	0.2	0.5	7.0±0.5	0.3±0.1	....	0.05	0.2	....	0.05 each
N..........	remainder	1.25±0.25	0.5	5.0±0.5	0.5±0.1	0.1	0.05	0.2	....	0.2

[a] Total of all elements other than aluminum not to exceed 13.5 per cent.

[b] Iron plus silicon not more than 2.0 per cent.

TABLE II.—PRECISION REQUIREMENTS FOR METHODS OF CHEMICAL ANALYSIS EXPRESSED IN PERCENTAGE OF THE SPECIFIED VALUE.[a]

NOTE.—By "precision" is meant that the difference between the largest and the smallest value obtained in four repeat analyses shall not exceed twice the percentage stated in this table.

Alloy	Copper	Iron	Silicon	Magnesium	Manganese	Titanium	Nickel	Zinc
C................	1	5	5	10	10	....	....	5
CC................	1	5	5	10	10	....	....	10
F................	2	5	5	10	10	....	....	10
G................	2	5	5	10	10	10	....	10
GG................	2	5	5	10	10	10	....	10
H................	2	5	10	5	10	....	1	10
J................	5	5	5	10	10	10	....	10
JJ................	10	5	5	10	10	10	....	10
K................	10	5	2	10	10	....	....	10
L................	10	5	10	5	10	10	....	10
M................	5	5	2	10	10	10	....	10
N................	2	5	5	10	10	10	....	10

[a] Where the amount of element present is expressed as a maximum, the precision is expressed in percentage of the maximum amount permitted.

Method of Chemical Analysis

6. The chemical analysis shall be made in accordance with the Tentative Methods of Chemical Analysis of Aluminum and Light Aluminum Alloys (A.S.T.M. Designation: B 40 - 36 T) of the American Society for

Testing Materials,[1] or by any other method which has the precision shown in Table II.

Physical Properties

7. The physical properties as determined from test specimens shall conform to the requirements specified in Table III.

Test Specimens

8. (*a*) The test specimens shall be separately cast in green sand and shall be cast to size according to the dimensions shown in Fig. 1.

(*b*) If the castings are to be heat treated, the test specimens representing such castings shall be heat treated with the castings they represent. They shall not be machined prior to test except to adapt the grip ends of the specimen to the jaws of the testing machine in such a manner as to assure axial loading.

TABLE III.—PHYSICAL PROPERTIES OF ALUMINUM-BASE ALLOY SAND CASTINGS.

NOTE.—See Explanatory Notes.

ALLOY	CONDITION	TENSILE STRENGTH, MIN., LB. PER SQ. IN. (TO THE NEAREST 1000 LB. PER SQ. IN.)	ELONGATION IN 2 IN., MIN., PER CENT (TO THE NEAREST 1 PER CENT)
C	As-cast	19 000	1[a]
CC	As-cast	19 000	3
F	As-cast	19 000	[b]
G	Heat Treatment No. 1	29 000	6
	Heat Treatment No. 2	32 000	3
	Heat Treatment No. 3	36 000	[b]
GG	Heat Treated	36 000	[b]
H	Heat Treated	32 000	[b]
J	As-cast	17 000	3
JJ	As-cast	17 000	3
K	As-cast	24 000	5
L	As-cast	22 000	6
M	Heat Treatment No. 1	26 000	5
	Heat Treatment No. 2	30 000	3
N	Heat Treatment No. 1	27 000	4
	Heat Treatment No. 2	32 000	2
	Heat Treatment No. 3	25 000	1[a]

[a] For information only.

[b] Not required.

Tension Tests

9. The tensile properties shall be determined in accordance with the Standard Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8) of the American Society for Testing Materials.[2]

Number of Tests

10. (*a*) The test specimens shall, so far as possible, be selected by heats or melts but, unless otherwise agreed upon by the purchaser or his representative and the manufacturer, two tension tests shall be made for each unit of 500 lb. or fraction thereof.

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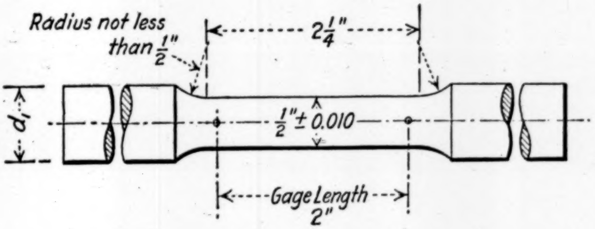
[1] A.S.T.M. Methods of Chemical Analyses of Metals, 1936.

[2] 1936 Book of A.S.T.M. Standards, Part I, p. 833.

(*b*) If any test specimen shows defective machining or flaws, it may be discarded; in which case the purchaser or his representative and the manufacturer shall agree upon the selection of another specimen in its stead.

Retests

11. If the results of the tension tests do not conform to the tensile properties specified in Section 9, the castings may be reheat-treated but not more than twice. The results of acceptable tests shall conform to the tensile property requirements as specified in Section 9.



NOTE:

The Gage Length, Parallel Section and Fillets shall be as shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a way, that the Load shall be Axial.

In Order to promote the Breaking of the Specimen in the Center it is permissible to use a Taper in the Reduced Section from the Fillets to the Center of not to exceed 0.010 in.

It is recommended, that Diameter d_1 be from 3/4" to 1."

FIG. 1.—Tension Test Specimen.

Inspection

12. (*a*) Inspection may be made at the manufacturer's works where the castings are made, or at the point at which they are received, at the option of the purchaser.

(*b*) The general requirements specified in Section 3 shall be checked by visual inspection of the castings or by comparison with observational standards where such standards are established. It is advisable that observational standards representing acceptable material be set up which will govern when any question arises as to what defects are allowable under the best commercial practice.

(*c*) If the purchaser elects to have inspection made at the manufacturer's works, the manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection

13. Castings which show injurious defects revealed by machining operations subsequent to acceptance may be rejected, and if rejected shall be replaced by the manufacturer without charge to the purchaser. The full weight of the original material rejected shall be returned to the manufacturer.

Rehearing

14. In the case of dissatisfaction regarding rejections based on chemical composition and tensile property requirements specified in Sections 6 and 9, respectively, the manufacturer may make claim for a rehearing as the basis of arbitration within five working days of receipt by the manufacturer of the rejection notification.

Explanatory Notes

Alloy C.—The specific gravity of Alloy C is about 2.83 to 2.86. The pattern shrinkage is about 0.156 ($\frac{5}{32}$) in. per ft. It has somewhat better machining qualities than Alloy CC. It is used for about the same purposes as Alloy CC, particularly for automotive work, such as crank and transmission cases and similar parts.

Alloy CC.—Alloy CC has a specific gravity of about 2.83. The pattern shrinkage is about 0.156 ($\frac{5}{32}$) in. per ft. It supersedes the 8 per cent copper alloy without silicon as it possesses better casting characteristics, especially in the more difficult work where higher pouring temperatures than those usually employed are found necessary. The tendency towards cracks and shrinks is considerably overcome by the careful control of the iron and silicon contents. This alloy is used for general casting purposes.

Alloy F.—The specific gravity of Alloy F is about 2.90 and the pattern shrinkage about 0.156 ($\frac{5}{32}$) in. per ft. This alloy is used for pistons, cylinder heads, valve guides, and bearings or other parts where hardness and good bearing qualities are essential. Together with Alloy H it possesses the property of retaining at higher temperatures a greater percentage of its room temperature strength than any other alloy in this group. This alloy may be heat treated, in which case substantially higher strength and hardness or other desirable characteristics are obtained.

Alloy G.—Alloy G has a specific gravity of about 2.78. It is used for general casting purposes where a combination of lightness, higher strength and ductility is desired. The various strengths are obtained through different heat treatments. Heat Treatment No. 1 gives maximum elongation and resistance to shock. It is a solution heat treatment and may be specified where the most rugged service is required. On standing at room temperatures, the alloy age hardens over a period of a few months to develop mechanical properties approaching those of Heat Treatment No. 2. Heat Treatment No. 2 is a solution and precipitation heat treatment, and should be specified where a higher initial strength, yield strength and hardness are desired. Heat Treatment No. 3 should be specified where the highest strength and hardness are desired and lower ductility is not objectionable. This alloy with the various heat treatments is used in general for high strength parts in street cars and busses, parts for internal combustion engines, outboard motor parts and other marine castings.

Alloy GG.—Alloy GG is used in the heat-treated condition where high strength and maximum hardness are desired, such as bearing caps.

Alloy H.—The specific gravity of Alloy H is about 2.80. It is usually employed in the heat-treated condition. The alloy is used for pistons, cylinder heads, valve guides and bearings or other parts where hardness or good bearing qualities are essential. Together with Alloy F it possesses the property of retaining at higher temperatures a greater percentage of its room-temperature strength than any other alloy in this group.

Alloy J.—Alloy J is somewhat lighter than aluminum, having a specific gravity of about 2.69. It withstands corrosion better than the copper alloys. The free flowing property of the alloy when molten makes it easier to pour castings of thin section or intricate design. Its leak proof properties are valuable where pressure tightness is essential. It has a lower strength and yield strength than the copper aluminum alloys and poorer machining qualities. It is especially suitable for automobile body parts, cooking utensils, architectural and marine castings.

Alloy JJ.—Alloy JJ is similar to Alloy J except that it is held to closer chemical composition limits which results in greater corrosion resistance.

Alloy K.—The specific gravity of Alloy K is about 2.68. Immediately before pouring, the alloy is treated by a process called "modification." Its corrosion resistance is good, especially to salt water. It has good foundry characteristics and can be used for castings having both thin and heavy sections. It is not as readily machined and has a lower yield strength in proportion to tensile strength than most of the copper-aluminum alloys. It is used for marine castings, bus, street car and engine parts, and for thin castings such as radiators, small motor housings and meter cases.

Alloy L.—Alloy L has the highest resistance to corrosion of any of the commercial aluminum casting alloys. It is not so easily cast as some of the other alloys, which fact should be considered when designing complicated castings. Its specific gravity is approximately 2.63.

Alloy M.—The specific gravity of Alloy M is approximately 2.65. It has casting qualities and resistance to corrosion comparable with those of Alloy J (see Note on Alloy J). Its higher mechanical properties result from heat treatment processes. The alloy in Heat Treatment No. 1 age hardens on standing at room temperatures and after a few months its mechanical properties approach those of Heat Treatment No. 2.

Alloy N.—Alloy N has a specific gravity of approximately 2.68. It has good casting qualities. It is used extensively for liquid cooled cylinder heads and other castings which are subjected to elevated temperatures in service. The alloy in Heat Treatment No. 1 age hardens and develops properties approaching those of Heat Treatment No. 2. Heat Treatment No. 3 is applied principally to castings which are to be used at high temperatures and serves to stabilize the dimensions under those conditions.

TENTATIVE SPECIFICATIONS

FOR

ALUMINUM-ALLOY (DURALUMIN) BARS, RODS AND SHAPES (ALUMINUM-COPPER-MAGNESIUM-MANGANESE)[1]

A.S.T.M. Designation: B 89 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1932; REVISED, 1933, 1936.[2]

By publication of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing the specifications against liability for infringement of Letters Patent nor assume any such liability, and such publication should not be construed as a recommendation of any patented or proprietary application that may be involved.

MANUFACTURE

Manufacture.

1. No scrap shall be used in the manufacture of the material except such as may accumulate in the manufacturer's own plants from material of similar composition and of his own manufacture.

CHEMICAL COMPOSITION AND TESTS

Chemical Composition.

2. The composition of the material as determined by chemical analysis shall conform to the following requirements:

Aluminum, minimum, per cent	92.0
Copper, per cent	3.5 to 4.5
Magnesium, per cent	0.2 to 0.75
Manganese, per cent	0.4 to 1.0

Chemical Analysis.

3. Samples for chemical analysis shall be taken from a random piece representing each lot of 2000 lb. or fraction thereof, or such other quantity as may be mutually agreed upon between the manufacturer and purchaser. Samples may be taken from tension or bend test specimens. The sample for analysis may be prepared by shearing or by drilling or machining without the use of any lubricant in such a manner as to give a sample representative of the entire cross-

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-7 on Light Metals and Alloys, Cast and Wrought.

[2] Latest revision accepted by Committee E-10 on Standards, November, 30, 1936.

section of the material. Samples so prepared shall be divided into three equal parts, each of which shall be placed in a sealed package, one for the manufacturer, one for the purchaser, and one for an umpire if necessary.

PHYSICAL PROPERTIES AND TESTS

Temper and Tensile Strength.

4. The material shall be supplied in the temper specified in the contract or purchase order and shall conform to the requirements as to tensile properties for the specified temper as shown in Table I.

TABLE I.—MECHANICAL PROPERTIES OF BARS, RODS AND SHAPES.

SECTION	DIAMETER OR LEAST DISTANCE ACROSS FLATS	TENSILE STRENGTH, LB. PER SQ. IN.	YIELD STRENGTH, MINIMUM, LB. PER SQ. IN.[a]	ELONGATION, MINIMUM, PER CENT[b]
		ANNEALED		
All sections	Up to 0.125 in., inclusive	35 000 max.	.....	..
	0.126 to 10.0 in.	35 000 max.	.....	16
		HEAT TREATED		
Rounds, Squares, Hexagons and Octagons	Up to 0.125 in.	55 000 min.	30 000	..
	0.126 to 0.750 in.	55 000 min.	30 000	18
	0.751 to 3.000 in.	53 000 min.	30 000	18
	3.001 to 8.000 in.	50 000 min.	28 000	16
Rectangles	Up to 0.750 in. thickness	53 000 min.	30 000	16
	0.751 to 3.000 in. thickness	50 000 min.	28 000	16
Structural shapes (rolled)[c]	....	50 000 min.	30 000	16
Extruded sections	....	50 000 min.	30 000	12

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[a] Yield strength is defined as the stress which produces a permanent set of 0.2 per cent of the initial gage length.

[b] The gage length for measurement of elongation shall be equal to four times the diameter or distance across flats except in sections for which a flat tension test specimen is used in which case the gage length shall be 2 in.

[c] Sizes as follows: Angles and Z-bars up to 6 by 6 in.; channels up to 10 in.; I-beams and H-beams up to 5 in. sizes in standard web or leg thicknesses.

Bend Test.

5. Bend test specimens shall stand being bent through an angle of 180 deg. around a diameter equal to four times the thickness of the specimen without cracking.

Test Specimens.

6. (*a*) Test coupons shall be selected at random to represent each lot of 2000 lb. or fraction thereof, or such other quantity as may be mutually agreed upon between the manufacturer and purchaser.

(*b*) The tension test specimen may be a full section of the material, or the standard 0.505-in. tension test specimens, Fig. 1, machined from the test coupon may be used. In the case of thin material the specimen may have the form and dimensions of the standard sheet tension test specimen having a width of ½ in. and a reduced section of 2¼ in. as shown in Fig. 2.

(*c*) The bend test specimen may be (*1*) a full section of the material or (*2*) a ¾-in. round specimen machined from the material or (*3*) a rectangular specimen approximately 1 in. in width and having the thickness of the section from which it is taken, or a ratio of width to thickness not less than six to one. The edges of the rectangular specimen may be rounded to a radius of approximately one-half the thickness.

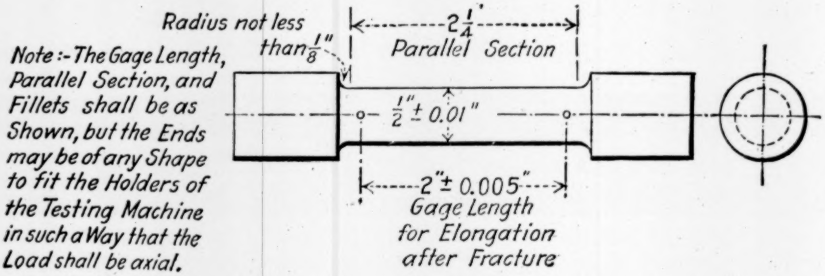
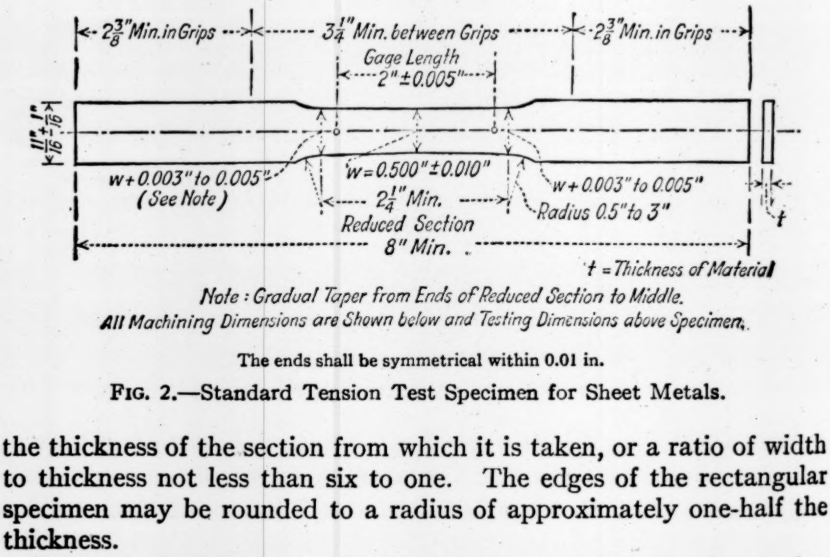

Radius not less than 1/8"
2 1/4"
Parallel Section
Note :- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.
1/2" ± 0.01"
2" ± 0.005"
Gage Length for Elongation after Fracture

FIG. 1.—Standard 2-in. Gage Length Tension Test Specimen.


2 3/8" Min. in Grips
3 1/4" Min. between Grips
2 3/8" Min. in Grips
Gage Length
2" ± 0.005"
11/16" ± 1/16"
w + 0.003" to 0.005" (See Note)
w = 0.500" ± 0.010"
w + 0.003" to 0.005"
2 1/4" Min. Reduced Section
Radius 0.5" to 3"
t
8" Min.
t = Thickness of Material
Note : Gradual Taper from Ends of Reduced Section to Middle.
All Machining Dimensions are Shown below and Testing Dimensions above Specimen.

The ends shall be symmetrical within 0.01 in.

FIG. 2.—Standard Tension Test Specimen for Sheet Metals.

(*d*) For material up to 1½ in. in diameter or thickness, the tension and bend test specimens shall be machined from the center of the section; for material 1½ in. and over, specimens shall be machined from the material midway between the center and the outside of the section. Specimens shall be taken parallel to the direction of rolling or extrusion.

PERMISSIBLE VARIATIONS IN DIMENSIONS

Permissible Variations.

7. Variations from the specified dimensions for the class of material ordered shall not exceed the amounts shown in Tables II and III.

WORKMANSHIP AND FINISH

Workmanship and Finish.

8. The material shall be of uniform quality and temper, clean, sound, smooth, commercially straight or flat and free from pipes, laps, cracks, twists, seams, damaged ends and other injurious defects.

TABLE II.—DIMENSIONS AND PERMISSIBLE VARIATIONS OF ALLOY BARS AND RODS.

COLD FINISHED ROUNDS, SQUARES, HEXAGONS AND OCTAGONS; ALSO RECTANGLES UP TO 3.00 IN. IN WIDTH, PROVIDED AREA IS NOT GREATER THAN 3 SQ. IN.

Diameter or Distance Across Flats, in.	Tolerance, in., plus or minus		
	Rounds	Squares, Hexagons, Octagons	Rectangles
Up to 0.0359	0.0005	.....	.....
0.036 to 0.064	0.001	0.0015	0.0015
0.065 to 0.500	0.0015	0.002	0.002
0.501 to 1.000	0.002	0.0025	0.0025
1.001 to 1.500	0.0025	0.003	0.003
1.501 to 3.00	......	......	0.005

ROLLED ROD

Diameter, in.	Tolerance, in.	
	Plus	Minus
1.501 to 3.499	0.008	0.008
3.500 to 5.000	$\frac{1}{32}$	$\frac{1}{64}$
5.001 to 8.000	$\frac{1}{16}$	$\frac{1}{32}$

ROLLED BAR (Including Squares, Hexagons, Octagons and Rectangles)

Least Distance Across Flats, in.	Tolerance, in., plus or minus
Up to 0.500	0.006
0.501 to 0.750	0.008
0.751 to 1.000	0.012
1.001 to 2.000	0.016
2.001 to 3.000	0.020
Width (of Rectangles), in.	
Up to 1.500	$\frac{1}{64}$
1.501 to 4.000	$\frac{1}{32}$
4.001 to 6.000	$\frac{3}{64}$
6.001 to 10.000	$\frac{1}{16}$

INSPECTION AND REJECTION

Inspection.

9. The manufacturer shall afford the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

Rejection.

10. Material which fails to conform to these specifications will be rejected and the manufacturer shall be notified.

TABLE III.—DIMENSIONS AND PERMISSIBLE VARIATIONS OF ALLOY SHAPES.

STRUCTURAL SHAPES, ROLLED

	Tolerance on Section Thickness
Channels up to 10 in. Angles and Z-bars up to 6 by 6 in.	$\pm 2\frac{1}{2}$ per cent of nominal thickness except that the tolerance shall not be less than ± 0.010 in.
	Tolerance on Over-all Dimensions
Angles and Z-bars up to 6 by 6 in.	Lengths of leg: $\pm 2\frac{1}{2}$ per cent of nominal lengths, except that the minimum tolerance shall be $\pm \frac{1}{16}$ in.
Channels up to 10 in.	Over-all width: $+\frac{3}{32}$ in. $-\frac{1}{16}$ in. Width of flange: ± 4 per cent of nominal width
	Tolerance on Weight
Angles and Z-bars from 3 by 3 in. to 6 by 6 in.	$\pm 2\frac{1}{2}$ per cent of the nominal weight for a lot or shipment.

SHAPES, EXTRUDED

Dimensions, in.	Tolerance, in., plus or minus
Up to 0.125, inclusive	0.010
0.126 to 0.500, inclusive	0.015
0.501 to 1.000, inclusive	0.020
1.001 to 2.000, inclusive	0.025
2.001 to 3.000, inclusive	0.030
3.001 to 4.000, inclusive	0.035
4.001 to 5.000, inclusive	0.040
5.001 to 6.000, inclusive	0.045
6.001 to 7.000, inclusive	0.050
7.001 to 8.000, inclusive	0.055
8.001 to 9.000, inclusive	0.060
9.001 to 10.000, inclusive	0.065
10.001 to 11.000, inclusive	0.070
11.001 to 12.000, inclusive	0.080

ROUNDS, SQUARES, RECTANGLES, HEXAGONS, OCTAGONS, BARS AND RODS, EXTRUDED

Dimensions, in.	Tolerance, in., plus or minus
Up to 0.500	0.007
0.501 to 1.000	0.010
1.001 to 2.000	0.012
2.001 to 3.000	0.015
3.001 and over	0.018

PERMISSIBLE VARIATIONS IN LENGTH

Length, ft.	Tolerance, in.
Up to 20	$+\frac{1}{4}$
Over 20 to 30	$+\frac{3}{8}$
Over 30 to 85	$+\frac{1}{2}$

TENTATIVE SPECIFICATIONS
FOR
ALUMINUM SHEET AND PLATE[1]

A.S.T.M. Designation: B 25 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED AS TENTATIVE, 1918; ADOPTED IN AMENDED FORM, 1929;
REISSUED AS TENTATIVE, 1933; REVISED, 1934, 1936.[2]

By publication of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing the specifications against liability for infringement of Letters Patent nor assume any such liability, and such publication should not be construed as a recommendation of any patented or proprietary application that may be involved.

Scope

1. These specifications cover aluminum sheet and plate. Commercial flat sheet shall be supplied on orders for sheet, except where coiled or strip sheet is specifically ordered.

Manufacture

2. No scrap shall be used in the manufacture of aluminum sheet and plate except such as shall accumulate at the manufacturer's plants from material of similar composition and of his own manufacture.

CHEMICAL COMPOSITION AND TESTS

Chemical Composition

3. The sheet and plate shall contain a minimum of 99 per cent aluminum as determined by chemical analysis.

Samples

4. Samples for analysis shall be taken from a random sheet to represent each 1000 lb. (453.6 kg.) of sheet, and from a random plate to represent each 2000 lb. (907.2 kg.) of plate, or such other quantity as may be mutually agreed upon between the manufacturer and the purchaser. Samples for analysis may be obtained from the tension or bend test specimens described in Section 7. The sample for analysis may be prepared by shearing or by drilling or machining without the use of any lubricant in such a manner as to give a sample representative of the entire cross-section of the sheet or plate. Samples so prepared shall be divided into three equal parts, each of which shall be placed

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-7 on Light Metals and Alloys, Cast and Wrought.

These specifications are in effect a revision of and replace the former Standard Specifications for Aluminum Sheet (A.S.T.M. Designation: B 25 - 29) which were accordingly discontinued in 1933.

[2] Latest revision accepted by Committee E-10 on Standards, November 30, 1936.

in a sealed package, one for the manufacturer, one for the purchaser and one for an umpire if necessary.

PHYSICAL PROPERTIES AND TESTS

Tensile Requirements

5. (*a*) Sheet shall be supplied in the temper specified in the contract or purchase order and shall conform to the following minimum requirements as to tensile properties for the specified temper and thickness:

TEMPER	THICKNESS, IN.	TENSILE STRENGTH, LB. PER SQ. IN.	ELONGATION IN 2 IN., MINIMUM, PER CENT
Soft	0.013 to 0.019	15 500 max.	15
	0.020 to 0.031	15 500 max.	20
	0.032 to 0.050	15 500 max.	25
	0.051 to 0.249	15 500 max.	30
Half Hard	0.013 to 0.019	16 000 min.	3[a]
	0.020 to 0.031	16 000 min.	4[a]
	0.032 to 0.050	16 000 min.	5[a]
	0.051 to 0.113	16 000 min.	7[a]
	0.114 to 0.249	16 000 min.	7
Three-quarter Hard	0.013 to 0.019	19 000 min.	1
	0.020 to 0.031	19 000 min.	2
	0.032 to 0.050	19 000 min.	3
	0.051 to 0.162	19 000 min.	4
Hard	0.013 to 0.019	22 000 min.	1
	0.020 to 0.031	22 000 min.	2
	0.032 to 0.050	22 000 min.	3
	0.051 to 0.128	22 000 min.	4

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[a] This value is required for flat sheet. For coiled sheet in the half-hard temper, the elongation may be less than that for flat sheet by 1 per cent in 2 in. The maximum thickness of coiled or strip sheet commercially available in the half-hard temper is 0.080 in.

(*b*) Unless otherwise specified, plate (thicknesses 0.250 in. and over) shall be supplied as rolled (see Explanatory Note 2) and tension tests shall not be required.

(*c*) If so specified, plate shall be supplied in the soft temper in thicknesses from 0.250 to 3.000 in., in which case the tensile strength shall not exceed 19,000 lb. per sq. in. and the elongation shall not be less than 25 per cent in 2 in.

Bend Tests

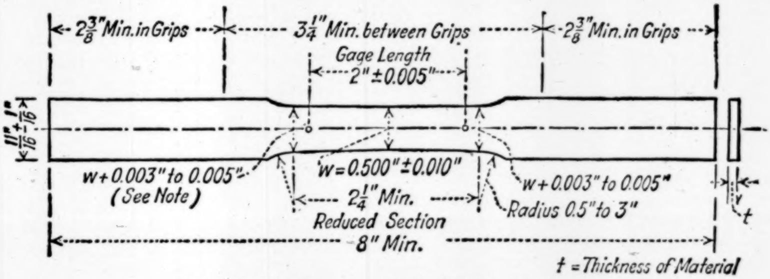
6. (*a*) Bend test specimens taken from sheet in the soft or in the half-hard temper or from plate in the soft temper or as rolled shall stand being bent cold through 180 deg. flat on themselves without cracking.

(*b*) Bend test specimens taken from sheet in the three-quarter-hard temper shall stand being bent cold through 180 deg. around a pin having a diameter equal to four times the thickness of the sheet without cracking.

(*c*) The bend test shall not be required for sheet in the hard temper.

Test Specimens

7. (*a*) *Tension Tests.*—Tension test specimens for sheet in the half-hard temper shall be taken parallel to the direction of rolling; for sheet in the soft, three-quarter-hard and hard tempers, the tension test specimens may be taken in any direction. (See Explanatory Notes 1 and 3.) For sheet and plate under 0.500 in. in thickness the standard sheet tension test specimen shown in Fig. 1 shall be used. For plate 0.500 in. or over in thickness, the standard 0.505-in. diameter round specimen shown in Fig. 2 or a similar round specimen having the maximum possible dimensions proportional to those of the standard 0.505-in. diameter specimen shall be used.


$2\frac{3}{8}$" Min. in Grips
$3\frac{1}{4}$" Min. between Grips
$2\frac{3}{8}$" Min. in Grips
Gage Length
2" ± 0.005"
$\frac{11}{16}$" ± $\frac{1}{16}$"
w + 0.003" to 0.005"
(See Note)
W = 0.500" ± 0.010"
$2\frac{1}{4}$" Min.
Reduced Section
w + 0.003" to 0.005"
Radius 0.5" to 3"
8" Min.
t
t = Thickness of Material

Note: Gradual Taper from Ends of Reduced Section to Middle.
All Machining Dimensions are Shown below and Testing Dimensions above Specimen.

The ends shall be symmetrical within 0.01 in.

FIG. 1.—Standard Tension Test Specimen for Sheet Metals.

Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

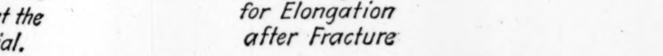

Radius not less than $\frac{1}{8}$"
$2\frac{1}{4}$'
Parallel Section
$\frac{1}{2}$" ± 0.01"
2" ± 0.005"
Gage Length for Elongation after Fracture

FIG. 2.—Standard 2-in. Gage Length Tension Test Specimen.

(*b*) *Bend Tests.*—Bend test specimens may be taken in any direction from sheet in the soft, half-hard or three-quarter-hard temper and from plate in the soft temper or as rolled. Bend test specimens from thin sheet and strip shall be of the full thickness, and in the case of strips $\frac{3}{4}$ in. in width or under, of the full width of the material. The width of specimens from material over $\frac{3}{4}$ in. in width shall be six times the thickness, but not less than $\frac{3}{4}$ in. The edges may be rounded to a $\frac{1}{16}$-in. radius. When practicable the length shall be at least 6 in. For plates over 0.500 in. in thickness a machined bend test specimen $\frac{3}{4}$ by $\frac{1}{2}$ in. in cross-section and at least 6 in. in length shall be used. The edges may be rounded to a $\frac{1}{16}$-in. radius. When permitted by the inspector, the cross-section may be modified to $\frac{1}{2}$ in. square. In the case of plate $\frac{3}{4}$ in. or over in thickness, a $\frac{3}{4}$-in. round specimen machined from the material may be used. From plate $1\frac{1}{2}$ in. or over in thickness, the specimen shall be taken midway between the center and surface of the plate.

Number of Tests

8. One tension and one bend test specimen shall be taken from a random sheet to represent each 1000 lb. (453.6 kg.) of sheet, and from a random plate to represent each 2000 lb. (907.2 kg.) of plate, or such other quantity as may be agreed upon between the manufacturer and the purchaser.

PERMISSIBLE VARIATIONS IN THICKNESS

9. The thickness of flat sheet, coiled or strip sheet, and plate, shall not vary from that specified by more than the respective tolerances indicated in the following table:

FLAT SHEET

	18 in. in Width and Under	Over 18 to 36 in., Incl., in Width	Over 36 to 54 in., Incl., in Width	Over 54 to 72 in., Incl., in Width	Over 72 to 90 in., Incl., in Width	Over 90 to 102 in., Incl., in Width
Thickness, in.	Thickness tolerance, plus or minus, in.					
0.249 to 0.129......	0.04T[a]	0.04T[a]	0.05T[a]	0.06T[a]	0.07T[a]	0.08T[a]
0.128 to 0.092......	0.004	0.0045	0.005	0.007	0.009	0.010
0.091 to 0.073......	0.003	0.003	0.004	0.006	0.008	......
0.072 to 0.051......	0.0025	0.003	0.004	0.005	0.007	......
0.050 to 0.037......	0.002	0.0025	0.003	0.004	......	......
0.036 to 0.018......	0.0015	0.002	0.0025	......	......	......
0.017 to 0.010......	0.0015	0.0015	0.002	......	......	......

COILED SHEET

	12 in. in Width and Under	Over 12 to 24 in., Incl., in Width	Over 24 in. in Width
Thickness, in.	Thickness tolerance, plus or minus, in.		
0.128 to 0.103....................	0.0035	0.0035	0.004
0.102 to 0.091....................	0.003	0.003	0.004
0.090 to 0.073....................	0.003	0.003	0.003
0.072 to 0.051....................	0.0025	0.003	0.003
0.050 to 0.041....................	0.0025	0.0025	0.0025
0.040 to 0.030....................	0.002	0.0025	0.0025
0.029 to 0.019....................	0.002	0.002	0.002
0.018 to 0.011....................	0.0015	0.002	......
0.010 to 0.008....................	0.001	0.0015	......
0.007 to 0.006....................	0.001	0.001	......

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[a] T = the nominal thickness.

PLATE

THICKNESS, IN.	54 IN. IN WIDTH AND UNDER	OVER 54 TO 72 IN., INCL., IN WIDTH	OVER 72 TO 90 IN., INCL., IN WIDTH	OVER 90 TO 120 IN., INCL., IN WIDTH
	THICKNESS TOLERANCE, PLUS OR MINUS, PER CENT OF NOMINAL THICKNESS			
3.000 to 1.001	3	3	4	5
1.000 to 0.501	4	4	5	6
0.500 to 0.375	5	5	6	7
0.374 to 0.250	5	6	7	8

WORKMANSHIP AND FINISH

Workmanship and Finish

10. All sheet and plate shall be commercially flat and free from buckles; they shall be free from injurious surface defects and shall have a workmanlike finish.

INSPECTION AND REJECTION

Inspection

11. The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

Rejection

12. Materials which fail to conform to these specifications will be rejected and the manufacturer shall be notified.

EXPLANATORY NOTES

NOTE 1.—In the case of sheet in the half-hard temper, there is an appreciable difference in the elongation depending upon the direction in which the test specimen is taken from the sheet. This measurement made parallel to the direction of final rolling is distinctly higher than if the specimen were cut perpendicular to this direction. This difference is not observed in hard or soft sheet. The inspection of half-hard sheet calls for the use of specimens parallel to the direction of final rolling because of the greater contrast with the values obtained from hard sheet. The fact that the bend-test specimens may be taken without regard to the direction of rolling is evidence that the lower elongation across the grain does not indicate a lack of workability.

NOTE 2.—The mechanical properties of "as rolled" plate lie between those of the soft temper and those of the half-hard temper. Thinner plates (up to about 0.5 in.), because of the cooling during the rolling operation, have strengths which average around the minimum for half-hard temper. As the thickness increases the properties approach those of the soft temper. Where higher properties are required it is more economical to use a stronger aluminum alloy rather than to specify an intermediate temper (half-hard or quarter-hard) because of the cost of cold rolling heavy plates.

NOTE 3.—The use of grips which insure a uniform axial loading of the test specimen is essential, if satisfactory results are to be obtained.

TENTATIVE SPECIFICATIONS

FOR

ALUMINUM-ALLOY (DURALUMIN) SHEET AND PLATE (ALUMINUM-COPPER-MAGNESIUM-MANGANESE)[1]

A.S.T.M. Designation: B 78 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED AS TENTATIVE, 1930; ADOPTED, 1931; REISSUED AS TENTATIVE, 1933; REVISED, 1936.[2]

By publication of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing the specifications against liability for infringement of Letters Patent nor assume any such liability, and such publication should not be construed as a recommendation of any patented or proprietary application that may be involved.

Manufacture

1. No scrap shall be used in the manufacture of aluminum-alloy (duralumin) sheet and plate except such as shall accumulate at the manufacturer's plants from material of similar composition and of his own manufacture.

CHEMICAL COMPOSITION AND TESTS

Chemical Composition

2. The sheet or plate shall conform to the following requirements as to chemical composition:

Aluminum, minimum, per cent	92
Copper, per cent	3.5 to 4.5
Magnesium, per cent	0.2 to 0.75
Manganese, per cent	0.4 to 1.0

Chemical Analysis

3. Samples for analysis shall be taken from a random sheet to represent each 1000 lb. (453.6 kg.) of sheet, and from a random plate to represent each 2000 lb. (907.2 kg.) of plate, or such other quantity as may be mutually agreed upon between the manufacturer and the purchaser. Samples for analysis may be obtained from the tension or bend test specimens described in Section 6. The sample for analysis may be prepared by shearing or by drilling or by machining without

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-7 on Light Metals and Alloys, Cast and Wrought.

These specifications are in effect a revision of and replace the former Standard Specifications for Aluminum-Alloy (Duralumin) Sheet (A.S.T.M. Designation: B 78 – 31) which were accordingly discontinued in 1933.

[2] Revision accepted by Committee E-10 on Standards, November 30, 1936.

the use of any lubricant in such a manner as to give a sample representative of the entire cross-section of the sheet or plate. Samples so prepared shall be divided into three equal parts, each of which shall be placed in a sealed package, one for the manufacturer, one for the purchaser and one for an umpire if necessary.

Physical Properties and Tests

Tensile Requirements

4. Sheet and plate shall be supplied in the temper specified in the contract or purchase order and shall conform to the following requirements as to tensile properties for the specified temper and thickness:

Temper	Thickness, in.	Tensile Strength, lb. per sq. in.	Yield Strength,[a] minimum, lb. per sq. in.	Elongation in 2 in., minimum, per cent	Bend Diameter, Factor, N
Annealed......	0.010 to 0.032...	35 000 max.	......	12	0
	0.033 to 0.064...	35 000 max.	......	12	1
	0.065 to 0.128...	35 000 max.	......	12	2
	0.129 to 0.258...	35 000 max.	......	12	4
	0.259 to 0.500...	35 000 max.	......	12	6
Heat Treated..	0.010 to 0.020...	55 000 min.	32 000	15	3
	0.021 to 0.036...	55 000 min.	32 000	18[b]	3
	0.037 to 0.128...	55 000 min.	32 000	18[b]	4
	0.129 to 0.258...	55 000 min.	32 000	15	6
	0.259 to 0.500...	55 000 min.	32 000	12	8
	0.501 to 1.250...	55 000 min.	32 000	10	..
Rolled After Heat Treating.........	0.020 to 0.031...	55 000 min.	42 000	10	3
	0.032 to 0.036...	55 000 min.	42 000	11	3
	0.037 to 0.064...	55 000 min.	42 000	12	4
	0.065 to 0.128...	55 000 min.	42 000	12	5
	0.129 to 0.188...	55 000 min.	42 000	12	8

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[a] Yield strength is defined as the stress which produces a permanent set of 0.2 per cent of the initial gage length.

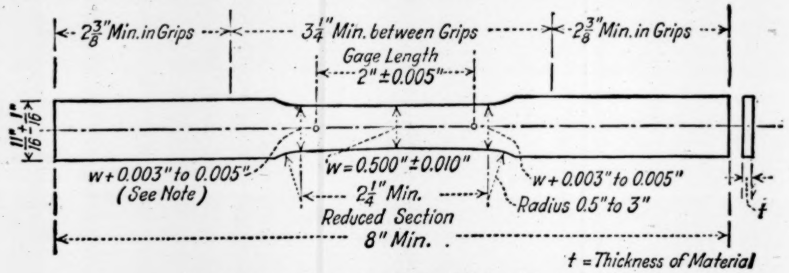
[b] For widths 36 in. or over, in thicknesses from 0.021 to 0.040 in., inclusive, the elongation may be 17 per cent in 2 in.

Bend Tests

5. Bend test specimens shall stand being bent cold through an angle of 180 deg. around a pin the diameter of which is equal to *N* times the thickness of the sheet without cracking; the value of *N* being shown in the table in Section 4 for the different tempers and thicknesses. No bend test is required for material in thicknesses greater than 0.500 in.

Test Specimens

6. (*a*) *Tension Tests.*—Tension test specimens for sheet and plate in either of the tempers may be cut in any direction, irrespective of the direction of rolling. For sheet and plate under 0.500 in. in thickness the standard sheet tension test specimen shown in Fig. 1 shall be used. For plate 0.500 in. or over in thickness, the standard 0.505-in. diameter round specimen shown in Fig. 2 or a similar round specimen having the maximum possible dimensions proportional to those of the standard 0.505-in. diameter specimen shall be used.


2⅜" Min. in Grips
3¼" Min. between Grips
2⅜" Min. in Grips
Gage Length
2" ± 0.005"
11/16" ± 1/16"
w + 0.003" to 0.005"
(See Note)
w = 0.500" ± 0.010"
w + 0.003" to 0.005"
2¼" Min.
Reduced Section
Radius 0.5" to 3"
8" Min.
t
t = Thickness of Material

Note: Gradual Taper from Ends of Reduced Section to Middle.
All Machining Dimensions are Shown below and Testing Dimensions above Specimen.

The ends shall be symmetrical within 0.01 in.

FIG. 1.—Standard Tension Test Specimen for Sheet Metals.

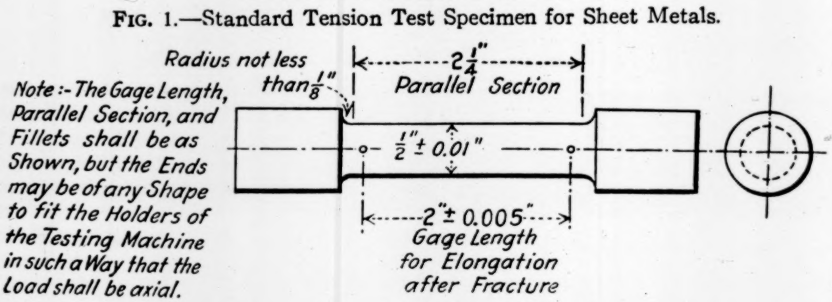

Radius not less than ⅛"
2¼"
Parallel Section
½" ± 0.01"
2" ± 0.005"
Gage Length for Elongation after Fracture
Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 2.—Standard 2-in. Gage Length Tension Test Specimen.

(*b*) *Bend Tests.*—Bend test specimens for sheet and plate in either of the tempers may be cut in any direction, irrespective of the direction of rolling. Bend test specimens from thin sheet and strip shall be of the full thickness, and in the case of strips ¾ in. in width or under, of the full width of the material. The width of specimens from material over ¾ in. in width shall be six times the thickness, but not less than ¾ in. The edges may be rounded to a 1/16-in. radius. When practicable the length shall be at least 6 in.

Number of Tests

7. One tension test specimen shall be taken to represent each 1000 lb. (453.6 kg.) or fraction thereof of sheet (thicknesses up to

0.258 in.); and one tension test specimen to represent each 2000 lb. (907.2 kg.) or fraction thereof of plate, or such other quantities as may be mutually agreed upon between the manufacturer and the purchaser. Bend test specimens for material up to 0.500 in. in thickness shall be taken in numbers equal to the tension test specimens.

PERMISSIBLE VARIATIONS IN THICKNESS

8. The thickness of sheet and plate shall not vary from that specified by more than the respective tolerances indicated in the following table:

SHEET

Thickness, in.	18 in. in Width and Under	Over 18 to 36 in., Incl., in Width	Over 36 to 54 in., Incl., in Width	Over 54 to 72 in., Incl., in Width	Over 72 to 90 in., Incl., in Width	Over 90 to 102 in., Incl., in Width
	Thickness Tolerances, plus or minus, in.					
0.249 to 0.129......	0.04T[a]	0.04T[a]	0.05T[a]	0.06T[a]	0.07T[a]	0.08T[a]
0.128 to 0.092......	0.004	0.0045	0.005	0.007	0.009	0.010
0.091 to 0.073......	0.003	0.003	0.004	0.006	0.008	......
0.072 to 0.051......	0.0025	0.003	0.004	0.005	0.007	......
0.050 to 0.037......	0.002	0.0025	0.003	0.004	......	......
0.036 to 0.018......	0.0015	0.002	0.0025	......	......	......
0.017 to 0.010......	0.0015	0.0015	0.002	......	......	......

PLATE

Thickness, in	54 in. in Width and Under	Over 54 to 72 in., Incl., in Width	Over 72 to 90 in., Incl., in Width	Over 90 to 120 in., Incl., in Width
	Thickness Tolerances, plus or minus, per cent of Nominal Thickness			
3.000 to 1.001...........................	3	3	4	5
1.000 to 0.501...........................	4	4	5	6
0.500 to 0.375...........................	5	5	6	7
0.374 to 0.250...........................	5	6	7	8

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[a] T = the nominal thickness.

WORKMANSHIP AND FINISH

Workmanship and Finish

9. All sheet and plate shall be commercially flat and free from buckles; they shall be free from injurious surface defects and shall have a workmanlike finish.

INSPECTION AND REJECTION

Inspection and Rejection

10. The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisy him that the material is being furnished in accordance with these specifications.

11. Material which fails to conform to these specifications will be rejected and the manufacturer shall be notified.

TENTATIVE SPECIFICATIONS
FOR
ALUMINUM-MANGANESE ALLOY SHEET AND PLATE[1]

A.S.T.M. Designation: B 79 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED AS TENTATIVE, 1930; ADOPTED, 1931; REISSUED AS TENTATIVE, 1933; REVISED, 1934, 1936.[2]

By publication of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing the specifications against liability for infringement of Letters Patent nor assume any such liability, and such publication should not be construed as a recommendation of any patented or proprietary application that may be involved.

Scope

1. These specifications cover aluminum-manganese alloy sheet and plate. Commercial flat sheet shall be supplied on orders for sheet, except where coiled or strip sheet is specifically ordered.

Manufacture

2. No scrap shall be used in the manufacture of aluminum-manganese alloy sheet and plate except such as shall accumulate at the manufacturer's plants from material of similar composition and of his own manufacture.

Chemical Composition

3. The sheet and plate shall conform to the following requirements as to chemical composition:

Aluminum, minimum, per cent	97.0
Manganese, per cent	1.0 to 1.5
Copper, maximum, per cent	0.2

Samples

4. Samples for analysis shall be taken from a random sheet to represent each 1000 lb. (453.6 kg.) of sheet, and from a random plate to represent each 2000 lb. (907.2 kg.) of plate, or such other quantity as may be mutually agreed upon between the manufacturer and the purchaser. Samples for analysis may be obtained from the tension or bend test specimens described in Section 7. The sample for analysis may be prepared by shearing or by drilling or by machining without the use of any lubricant in such a manner as to give a sample representative of the entire cross-section of the sheet or plate. Samples

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-7 on Light Metals and Alloys, Cast and Wrought.

These specifications are in effect a revision of and replace the former Standard Specifications for Aluminum-Manganese Alloy Sheet (A.S.T.M. Designation: B 79 – 31) which were accordingly discontinued in 1933.

[2] Latest revision accepted by Committee E-10 on Standards, November 30, 1936.

so prepared shall be divided into three equal parts, each of which shall be placed in a sealed package, one for the manufacturer, one for the purchaser and one for an umpire if necessary.

Tensile Requirements

5. (*a*) Sheet shall be supplied in the temper specified in the contract or purchase order and shall conform to the following requirements as to tensile properties for the specified temper and thickness:

TEMPER	THICKNESS, IN.	TENSILE STRENGTH, LB. PER SQ. IN.	ELONGATION IN 2 IN., MINIMUM, PER CENT
Soft	0.013 to 0.031	19 000 max.	20
	0.032 to 0.050	19 000 max.	23
	0.051 to 0.249	19 000 max.	25
Half hard	0.013 to 0.019	19 500 min.	3[a]
	0.020 to 0.031	19 500 min.	4[a]
	0.032 to 0.050	19 500 min.	5[a]
	0.051 to 0.113	19 500 min.	6[a]
	0.114 to 0.161	19 500 min.	7
	0.162 to 0.249	19 500 min.	8
Three-quarter hard	0.013 to 0.019	23 500 min.	1
	0.020 to 0.031	23 500 min.	2
	0.032 to 0.050	23 500 min.	3
	0.051 to 0.162	23 500 min.	4
Hard	0.013 to 0.019	27 000 min.	1
	0.020 to 0.031	27 000 min.	2
	0.032 to 0.050	27 000 min.	3
	0.051 to 0.128	27 000 min.	4

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[a] This value is required for flat sheet. For coiled sheet in the half-hard temper, the elongation may be less than that for flat sheet by 1 per cent in 2 in. The maximum thickness of coiled or strip sheet commercially available in the half-hard temper is 0.080 in.

(*b*) Unless otherwise specified, plate (thicknesses 0.250 in. and over) shall be supplied as rolled (see Explanatory Note 2) and tension tests shall not be required.

(*c*) If so specified, plate shall be supplied in the soft temper in thicknesses from 0.250 to 3.000 in., in which case the tensile strength shall not exceed 19,000 lb. per sq. in. and the elongation shall not be less than 25 per cent in 2 in.

Bend Tests

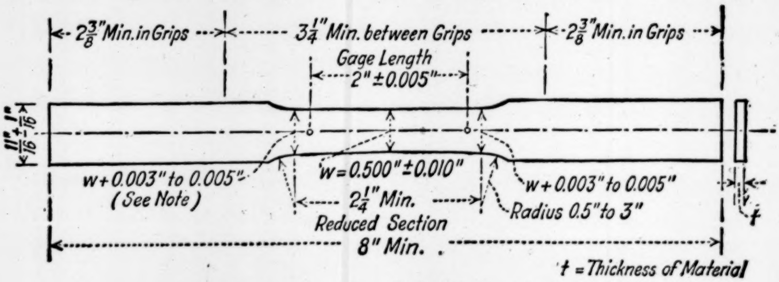
6. (*a*) Bend test specimens taken from sheet in the soft or in the half-hard temper or from plate in the soft temper or "as rolled" shall stand being bent cold through 180 deg. flat on themselves without cracking.

(*b*) Bend test specimens taken from sheet in the three-quarter-hard temper shall stand being bent cold through 180 deg. around a pin having a diameter equal to four times the thickness of the sheet without cracking.

(*c*) The bend test shall not be required for sheet in the hard temper.

Test Specimens

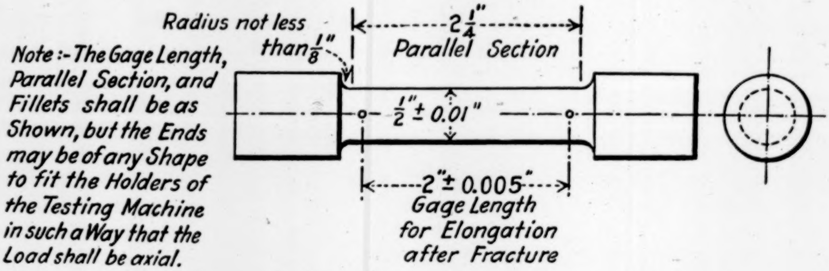
7. (*a*) *Tension Test Specimens.*—Tension test specimens for sheet in the half-hard temper shall be taken parallel to the direction of rolling; for sheet in the soft, three-quarter-hard and hard tempers the tension test specimens may be taken in any direction. (See Explanatory Notes 1 and 3.) For sheet and plate under 0.500 in. in thickness the standard sheet tension test specimen shown in Fig. 1 shall be used. For plate 0.500 in. or over in thickness, the standard 0.505-in. diameter round specimen shown in Fig. 2 or a similar round specimen having the maximum possible dimensions proportional to those of the standard 0.505-in. diameter specimen shall be used.


2 3/8" Min. in Grips
3 1/4" Min. between Grips
2 3/8" Min. in Grips
Gage Length
2" ± 0.005"
11/16" ± 1/16"
w + 0.003" to 0.005"
(See Note)
w = 0.500" ± 0.010"
w + 0.003" to 0.005"
2 1/4" Min.
Reduced Section
Radius 0.5" to 3"
8" Min.
t
t = Thickness of Material

Note: Gradual Taper from Ends of Reduced Section to Middle.
All Machining Dimensions are Shown below and Testing Dimensions above Specimen.

The ends shall be symmetrical within 0.01 in.

FIG. 1.—Standard Tension Test Specimen for Sheet Metals.


Radius not less than 1/8"
2 1/4"
Parallel Section
1/2" ± 0.01"
2" ± 0.005"
Gage Length for Elongation after Fracture

Note:-The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 2.—Standard 2-in. Gage Length Tension Test Specimen.

(*b*) *Bend Test Specimens.*—Bend test specimens may be taken in any direction from sheet in the soft, half-hard or three-quarter-hard temper and from plate in the soft temper or as rolled. Bend test specimens from thin sheet and strip shall be of the full thickness, and in the case of strips $\frac{3}{4}$ in. in width or under, of the full width of the material. The width of specimens from material over ¾ in. in width shall be six times the thickness, but not less than ¾ in. The edges may be rounded to a $\frac{1}{16}$-in. radius. When practicable the length shall be at least 6 in. For plates over 0.500 in. in thickness a machined bend test specimen ¾ by ½ in. in cross-section and at least 6 in. in length shall be used. The edges may be rounded to a $\frac{1}{16}$-in. radius. When permitted by the inspector, the cross-section may be modified to ½ in. square. In the case of plate ¾ in. or over in thickness, a ¾-in. round specimen machined from the material may be used. From plate 1½ in. or over in thickness, the specimen shall be taken midway between the center and surface of the plate.

Number of Tests

8. One tension and one bend test specimen shall be taken from a random sheet to represent each 1000 lb. (453.6 kg.) of sheet, and from a random plate to represent each 2000 lb. (907.2 kg.) of plate, or such other quantity as may be mutually agreed upon between the manufacturer and the purchaser.

Thickness

9. The thickness of flat sheet, coiled or strip sheet, and plate, shall not deviate from that specified by more than the respective tolerances indicated in the following table:

FLAT SHEET

	18 IN. IN WIDTH AND UNDER	OVER 18 TO 36 IN., INCL., IN WIDTH	OVER 36 TO 54 IN., INCL., IN WIDTH	OVER 54 TO 72 IN., INCL., IN WIDTH	OVER 72 TO 90 IN., INCL., IN WIDTH	OVER 90 TO 102 IN., INCL., IN WIDTH
THICKNESS, IN.	THICKNESS TOLERANCE, PLUS OR MINUS, IN.					
0.249 to 0.129......	0.04T[a]	0.04T[a]	0.05T[a]	0.06T[a]	0.07T[a]	0.08T[a]
0.128 to 0.092......	0.004	0.0045	0.005	0.007	0.009	0.010
0.091 to 0.073......	0.003	0.003	0.004	0.006	0.008	......
0.072 to 0.051......	0.0025	0.003	0.004	0.005	0.007	......
0.050 to 0.037......	0.002	0.0025	0.003	0.004	......	......
0.036 to 0.018......	0.0015	0.002	0.0025	......	......	......
0.017 to 0.010......	0.0015	0.0015	0.002	......	......	......

[a] T = the nominal thickness.

COILED SHEET

	12 IN. IN WIDTH AND UNDER	OVER 12 TO 24 IN., INCL., IN WIDTH	OVER 24 IN. IN WIDTH
THICKNESS, IN.	THICKNESS TOLERANCE, PLUS OR MINUS, IN.		
0.128 to 0.103....................	0.0035	0.0035	0.004
0.102 to 0.091....................	0.003	0.003	0.004
0.090 to 0.073....................	0.003	0.003	0.003
0.072 to 0.051....................	0.0025	0.003	0.003
0.050 to 0.041....................	0.0025	0.0025	0.0025
0.040 to 0.030....................	0.002	0.0025	0.0025
0.029 to 0.019....................	0.002	0.002	0.002
0.018 to 0.011....................	0.0015	0.002	......
0.010 to 0.008....................	0.001	0.0015	......
0.007 to 0.006....................	0.001	0.001	......

PLATE

THICKNESS, IN.	54 IN. IN WIDTH AND UNDER	OVER 54 TO 72 IN., INCL., IN WIDTH	OVER 72 TO 90 IN., INCL., IN WIDTH	OVER 90 TO 120 IN., INCL., IN WIDTH
	THICKNESS TOLERANCE, PLUS OR MINUS, PER CENT OF NOMINAL THICKNESS			
3.000 to 1.001	3	3	4	5
1.000 to 0.501	4	4	5	6
0.500 to 0.375	5	5	6	7
0.374 to 0.250	5	6	7	8

Workmanship and Finish

10. All sheet and plate shall be commercially flat and free from buckles; they shall be free from injurious surface defects and shall have a workmanlike finish.

Inspection

11. The manufacturer shall afford the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

Rejection

12. Material which fails to conform to these specifications will be rejected and the manufacturer shall be notified.

EXPLANATORY NOTES

NOTE 1.—In the case of sheet in the half-hard temper, there is an appreciable difference in the elongation depending upon the direction in which the test specimen is taken from the sheet. This measurement made parallel to the direction of final rolling is distinctly higher than if the specimen were cut perpendicular to this direction. This difference is not observed in hard or soft sheet. The inspection of half-hard sheet calls for the use of specimens parallel to the direction of final rolling because of the greater contrast with the values obtained from hard sheet. The fact that the bend test specimens may be taken without regard to the direction of rolling is evidence that the lower elongation across the grain does not indicate a lack of workability.

NOTE 2.—The mechanical properties of "as rolled" plate lie between those of the soft temper and those of the half-hard temper. Thinner plates (up to about 0.5 in.), because of the cooling during the rolling operation, have strengths which average around the minimum for half-hard temper. As the thickness increases the properties approach those of the soft temper. Where higher properties are required it is more economical to use a stronger aluminum alloy rather than to specify an intermediate temper (half-hard or quarter-hard) because of the cost of cold rolling heavy plates.

NOTE 3.—The use of grips which insure a uniform axial loading of the test specimen is essential, if satisfactory results are to be obtained.

TENTATIVE SPECIFICATIONS
FOR
ALUMINUM-MAGNESIUM-CHROMIUM ALLOY SHEET AND PLATE[1]

A.S.T.M. Designation: B 109 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1936.[2]

By publication of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing the specifications against liability for infringement of Letters Patent nor assume any such liability, and such publication should not be construed as a recommendation of any patented or proprietary application that may be involved.

Scope

1. These specifications cover aluminum-magnesium-chromium alloy sheet and plate. Commercial flat sheet shall be supplied on orders for sheet, except where coiled or strip sheet is specifically ordered.

Manufacture

2. No scrap shall be used in the manufacture of aluminum-magnesium-chromium alloy sheet and plate except such as shall accumulate at the manufacturer's plants from material of similar composition and of his own manufacture.

Chemical Composition

3. The sheet and plate shall conform to the following requirements as to chemical composition:

Magnesium, per cent		2.2 to 2.8
Chromium, per cent		0.15 to 0.35
Iron plus silicon, max., per cent		0.45
Copper, max., per cent		0.10
Manganese, max., per cent		0.10
Other elements	each, max., per cent	0.03
	total, max., per cent	0.10
Aluminum, per cent		remainder

NOTE 1.—Analysis shall regularly be made only for the elements specifically mentioned in Section 3. If, however, the presence of other elements is indicated in the course of routine analysis, further analysis shall be made to determine that the total of these other elements is not present in excess of the limits specified in Section 3.

NOTE 2.—The following applies to all specified limits in Section 3: For purposes of acceptance and rejection, an observed value or a calculated value obtained from analysis should be rounded off to the nearest unit in the last right-hand place of figures used in expressing the specified limit.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-7 on Light Metals and Alloys, Cast and Wrought.

[2] Accepted as tentative by Committee E-10 on Standards, November 30, 1936.

Samples for Chemical Analysis

4. Samples for analysis shall be taken from a random sheet to represent each 1000 lb. (453.6 kg.) of sheet, and from a random plate to represent each 2000 lb. (907.2 kg.) of plate, or such other quantity as may be mutually agreed upon between the manufacturer and the purchaser. Samples for analysis may be obtained from the tension or bend test specimens described in Section 7. The sample for analysis may be prepared by shearing or by drilling or by machining without the use of any lubricant in such a manner as to give a sample representative of the entire cross-section of the sheet or plate. Samples so prepared shall be divided into three equal parts, each of which shall be placed in a sealed package, one for the manufacturer, one for the purchaser and one for an umpire if necessary.

Tensile Requirements

5. (*a*) *Sheet.*—Sheet shall be supplied in the temper specified in the contract or purchase order and shall conform to the following requirements as to tensile properties of the specified temper and thickness:

TEMPER	THICKNESS, IN.	TENSILE STRENGTH, LB. PER SQ. IN.	ELONGATION IN 2 IN., MIN., PER CENT	BEND FACTOR, *N*
Soft	0.013 to 0.019	31 000 max.	15	0[b]
	0.020 to 0.031	31 000 max.	18	0[b]
	0.032 to 0.050	31 000 max.	20	0[b]
	0.051 to 0.249	31 000 max.	20	0[b]
One-quarter hard	0.016 to 0.019	31 000 min.	5[a]	0[b]
	0.020 to 0.050	31 000 min.	6[a]	1
	0.051 to 0.113	31 000 min.	8[a]	2
	0.114 to 0.249	31 000 min.	10[a]	3
Half hard	0.013 to 0.019	34 000 min.	4[a]	1
	0.020 to 0.050	34 000 min.	5[a]	2
	0.051 to 0.113	34 000 min.	7[a]	2
	0.114 to 0.249	34 000 min.	8[a]	3
Three-quarter hard	0.013 to 0.031	37 000 min.	3	4
	0.032 to 0.162	37 000 min.	4	5
Hard	0.013 to 0.031	39 000 min.	3	..
	0.032 to 0.125	37 000 min.	4	..

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[a] This value is required for flat sheet; for coiled sheet in the one-quarter hard and half-hard tempers, the value may be less than that for flat sheet by 1 per cent in 2 in. The maximum thickness of coiled sheet commercially available in the one-quarter hard temper is 0.102 in., and in the half-hard temper is 0.060 in.

[b] Flat on itself.

(*b*) *Plate.*—Unless otherwise specified, plate in thicknesses 0.250 in. and over shall be supplied as rolled (see Explanatory Note 2) and tension tests shall not be required. If so specified, plate shall be supplied in the soft temper in thicknesses from 0.250 to 3.000 in., in which case the tensile strength shall not exceed 31,000 lb. per sq. in. and the elongation shall not be less than 20 per cent in 2 in.

Bend Tests

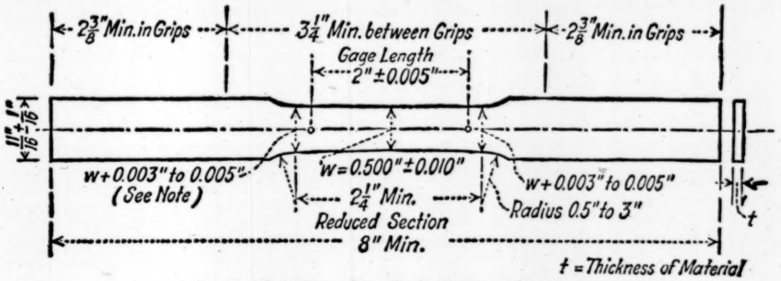
6. (*a*) Bend test specimens taken from sheet shall stand being bent cold, without cracking, through an angle of 180 deg. around a pin the

diameter of which is equal to N times the thickness of the sheet where N has the value shown in Section 5. Bend tests shall not be required for sheet in the hard temper.

(*b*) Bend test specimens taken from plate shall stand being bent cold, without cracking, through an angle of 180 deg. around a pin the diameter of which is equal to three times the thickness of the specimen.

Test Specimens

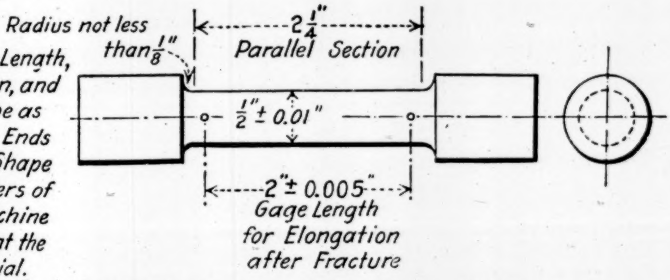
7. (*a*) *Tension Test Specimens.*—Tension test specimens shall be taken from sheet in the one-quarter-hard and half-hard tempers parallel to the direction of rolling; from sheet in the soft, three-quarter-hard and hard tempers the tension test specimens may be taken in any direction (see Explanatory Notes 1 and 3). For sheet and plate under 0.500 in. in thickness the standard sheet tension test specimen shown in Fig. 1 shall be used. For plate 0.500 in. or over in thickness, the standard 0.505-in. diameter round specimen shown in Fig. 2 or a similar round specimen having the maximum possible dimensions proportional to those of the standard 0.505-in. diameter specimen shall be used.


2 3/8" Min. in Grips
3 1/4" Min. between Grips
2 3/8" Min. in Grips
Gage Length
2" ± 0.005"
11/16" ± 1/16"
w + 0.003" to 0.005"
(See Note)
w = 0.500" ± 0.010"
2 1/4" Min.
Reduced Section
w + 0.003" to 0.005"
Radius 0.5" to 3"
8" Min.
t
t = Thickness of Material

Note: Gradual Taper from Ends of Reduced Section to Middle.
All Machining Dimensions are Shown below and Testing Dimensions above Specimen.

The ends shall be symmetrical within 0.01 in.

FIG. 1.—Standard Tension Test Specimen for Sheet Metals.


Radius not less than 1/8"
2 1/4"
Parallel Section
1/2" ± 0.01"
2" ± 0.005"
Gage Length for Elongation after Fracture

Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 2.—Standard 2-in. Gage Length Tension Test Specimen.

(*b*) *Bend Test Specimens.*—Bend test specimens may be taken in any direction from sheet in the soft, one-quarter-hard, half-hard or three-quarter-hard tempers and from plate in the soft temper or as rolled. Bend test specimens from thin sheet and strip shall be of the full thickness, and in the case of strips ¾ in. in width or under, of the full width of the material. The width of specimens from material over ¾ in. in width shall be six times the thickness, but not less than ¾ in. The edges may be rounded to a $\frac{1}{16}$-in. radius. When practicable the length shall be at least 6 in. For plates over 0.500 in. in thickness a machined bend test specimen ¾ by ½ in. in cross-section and at least 6 in. in length shall be used. The edges may be rounded to a $\frac{1}{16}$-in. radius. When permitted by the inspector representing the purchaser, the cross-section may be modified to ½ in. square. In the case of plate ¾ in. or over in thickness, a ¾-in. round specimen machined from the material may be used. From plate 1½ in. or over in thickness, the specimen shall be taken midway between the center and surface of the plate.

Number of Tests

8. One tension and one bend test specimen shall be taken from a random sheet to represent each 1000 lb. (453.6 kg.) of sheet, and from a random plate to represent each 2000 lb. (907.2 kg.) of plate, or such other quantity as may be mutually agreed upon between the manufacturer and the purchaser.

Thickness

9. The thickness of flat sheet, coiled or strip sheet, and plate, shall not deviate from that specified by more than the respective tolerances indicated in the following table:

FLAT SHEET

	36 IN. IN WIDTH AND UNDER	OVER 36 TO 54 IN., INCL., IN WIDTH	OVER 54 TO 60 IN., INCL., IN WIDTH
THICKNESS, IN.	THICKNESS TOLERANCE, PLUS OR MINUS, IN.		
0.249 to 0.126	0.04T[a]	0.05T[a]	0.06T[a]
0.125 to 0.092	0.0045	0.005	0.007
0.091 to 0.073	0.003	0.004	0.006
0.072 to 0.051	0.003	0.004	0.005
0.050 to 0.037	0.0025	0.003	......
0.036 to 0.025	0.0025	0.003	......
0.024 to 0.016	0.002	......	......
0.015 to 0.010	0.0015	......	......

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[a] T = the nominal thickness.

COILED SHEET

	12 IN. IN WIDTH AND UNDER	OVER 12 TO 24 IN., INCL., IN WIDTH	OVER 24 IN. IN WIDTH
THICKNESS, IN.	THICKNESS TOLERANCE, PLUS OR MINUS, IN.		
0.128 to 0.103	0.0035	0.0035	0.004
0.102 to 0.091	0.003	0.003	0.004
0.090 to 0.073	0.003	0.003	0.003
0.072 to 0.051	0.0025	0.003	0.003
0.050 to 0.041	0.0025	0.0025	0.0025
0.040 to 0.030	0.002	0.0025	0.0025
0.029 to 0.019	0.002	0.002	0.002
0.018 to 0.011	0.0015	0.002	......
0.010 to 0.008	0.001	0.0015	......
0.007 to 0.006	0.001	0.001	......

PLATE

THICKNESS, IN.	54 IN. IN WIDTH AND UNDER	OVER 54 TO 60 IN., INCL., IN WIDTH
	THICKNESS TOLERANCE, PLUS OR MINUS, PER CENT OF NOMINAL THICKNESS	
3.000 to 1.001	3	3
1.000 to 0.501	4	4
0.500 to 0.375	5	5
0.374 to 0.250	5	6

Workmanship and Finish

10. All sheet and plate shall be commercially flat and free from buckles; they shall be free from injurious surface defects and shall have a workmanlike finish.

Inspection

11. The manufacturer shall afford the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with those specifications.

Rejection

12. Material which fails to conform to these specifications will be rejected and the manufacturer shall be notified.

EXPLANATORY NOTES

NOTE 1.—In the case of sheet in the half-hard temper, there is an appreciable difference in the elongation depending upon the direction in which the test specimen is taken from the sheet. This measurement made parallel to the direction of final rolling is distinctly higher than if the specimen were cut perpendicular to this direction. This difference is not observed in hard or soft sheet. The inspection of half-hard sheet calls for the use of specimens parallel to the direction of final rolling because of the greater contrast with the values obtained from hard sheet. The fact that the bend test specimens may be taken without regard to the direction of rolling is evidence that the lower elongation across the grain does not indicate a lack of workability.

NOTE 2.—The mechanical properties of "as rolled" plate lie between those of the soft temper and those of the half-hard temper. Thinner plates (up to about 0.5 in.), because of the cooling during the rolling operation, have strengths which average around the minimum for half-hard temper. As the thickness increases the properties approach those of the soft temper. Where higher properties are required it is more economical to use a stronger aluminum alloy rather than to specify an intermediate temper (half-hard or quarter-hard) because of the cost of cold rolling heavy plates.

NOTE 3.—The use of grips which insure a uniform axial loading of the tension test specimen is essential, if satisfactory results are to be obtained.

TENTATIVE SPECIFICATIONS
FOR
MAGNESIUM INGOT AND STICK FOR REMELTING[1]

A.S.T.M. Designation: B 92 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1933; REVISED, 1936.

By publication of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing the specifications against liability for infringement of Letters Patent nor assume any such liability, and such publication should not be construed as a recommendation of any patented or proprietary application that may be involved.

Scope

1. These specifications cover magnesium ingot and stick in one grade containing not less than 99.8 per cent magnesium.

NOTE.—Magnesium ingot and stick are normally furnished in the following commercial forms unless otherwise specified in the contract:

	SIZE AND SHAPE		
FORM	DIAMETER, IN.	LENGTH, IN.	APPROXIMATE WEIGHT, LB.
Ingot (4 notches)	4 by 4	28	17.0
Stick	0.65	12	0.25
	0.92	12	0.50
	1.3	12	1.0
	1.3	24	2.0

Manufacture

2. No scrap shall be used in the production of magnesium ingot and stick, except such as shall accumulate at the manufacturer's plants from material of similar composition and of his own manufacture.

3. Magnesium ingot and stick shall have a clean surface and shall be commercially free from dirt, slag, or other foreign material.

Chemical Composition

4. The material shall conform to the following requirements as to chemical composition:

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[1] **Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-7 on Light Metals and Alloys, Cast and Wrought.**

Total of Aluminum, Copper, Iron, Manganese, Nickel, Silicon, max., per cent	0.20
Total of Copper and Nickel, max., per cent	0.05
Magnesium, by difference, min., per cent	99.80

Claims

5. Claims to be considered shall be made in writing within thirty days of receipt of material at the purchaser's plant and the results of the purchaser's tests shall be given. The seller shall within ten days of receipt of such claims either agree to satisfy the claims or send a representative to the purchaser's plant to endeavor to reconcile the differences. In the event of failure to reach an agreement the shipment shall be sampled as follows:

If the magnesium was shipped in carload lots, random samples shall be taken, but not less than four ingots from each car. If the shipment is less than carload lots, one ingot shall be taken from each 10,000 lb. or fraction thereof.

Sampling for Umpire Analysis

6. The ingot or stick selected shall be sawed or machined completely through with a clean tool. The sample so obtained shall represent the average cross-section of the material. No lubricant shall be used in this sampling operation. The metal chips shall be thoroughly mixed and the sample for analysis shall not be less than 100 g. Samples so taken shall be sealed and submitted to a mutually agreed upon umpire, whose determination shall be final.

Settlement of Claims

7. The expense of the umpire analysis shall be paid by the loser, or divided in proportion to the concession made in case of a compromise. In case of rejection being established, the damage shall be limited to the payment of freight both ways by the seller for the substitution of an equivalent weight of metal meeting these specifications.

TENTATIVE SPECIFICATIONS
FOR
MAGNESIUM-BASE ALLOY INGOT FOR REMELTING[1]

A.S.T.M. Designation: B 93 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934; REVISED, 1936.

By publication of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing the specifications against liability for infringement of Letters Patent nor assume any such liability, and such publication should not be construed as a recommendation of any patented or proprietary application that may be involved.

Scope

1. These specifications cover commercial magnesium-base alloys in ingot form for remelting (Note 1). These alloys have a specific gravity of 1.9 or less. Eleven alloys are specified and are designated Alloys Nos. 1 to 11, inclusive (Note 2).

NOTE 1.—Magnesium-base alloy ingots for remelting are normally furnished in the form of notched ingots 4 by $4\frac{1}{2}$ by $26\frac{1}{2}$ in. (4 notches) weighing approximately 18 lb., unless otherwise specified in the contract.

NOTE 2.—Explanatory Notes pertaining to the alloys covered by these specifications when used in the form of die castings, sand castings, sheet, and forgings are given in connection with the following tentative specifications of the American Society for Testing Materials: Tentative Specifications for Magnesium-Base Alloy Die-Castings (A.S.T.M. Designation: B 94 – 34 T);[2] for Magnesium-Base Alloy Sand Castings (A.S.T.M. Designation: B 80 – 36 T);[3] for Magnesium-Base Alloy Sheet (A.S.T.M. Designation: B 90 – 36 T);[3] for Magnesium-Base Alloy Forgings (A.S.T.M. Designation: B 91 – 36 T);[3] and for Magnesium-Base Alloy Bars, Rods, and Shapes (A.S.T.M. Designation: B 107 – 36 T).[3]

Manufacture

2. (*a*) The alloys may be made from virgin metal or from purified scrap metal of known composition.

(*b*) The ingots shall be uniform in quality and shall be commercially free from slag or other foreign material.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-7 on Light Metals and Alloys, Cast and Wrought.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, p. 703 (1934); also 1936 Book of A.S.T.M. Tentative Standards, p. 353.

[3] See pp. 708, 712, 716, and 720.

Chemical Composition

3. The alloys shall conform to the following requirements as to chemical composition.

Alloy	Magnesium, per cent	Aluminum, per cent	Manganese, min., per cent	Zinc, per cent	Copper, per cent	Cadmium, per cent	Tin, per cent	Silicon, max., per cent	Other Impurities,[a] max., per cent
No. 1....	remainder	8.0 to 9.0	0.18	....	0.04 max.	....	....	0.2	0.3
No. 2....	remainder	9.4 to 10.6	0.13	....	0.04 max.	....	....	0.2	0.3
No. 3....	remainder	11.5 to 12.5	0.13	.....	0.04 max.	....	....	0.2	0.3
No. 4....	remainder	5.5 to 6.5	0.18	2.7 to 3.3	0.04 max.	....	....	0.2	0.3
No. 5....	remainder	1.7 to 2.3	0.20	....	3.3 to 4.7	1.7 to 2.3	....	0.2	0.3
No. 6....	remainder	3.5 to 4.5	0.25	....	0.04 max.	....	....	0.2	0.3
No. 7....	remainder	6.0 to 7.0	0.20	....	0.04 max.	....	....	0.2	0.3
No. 8....	remainder	6.0 to 7.0	0.20	0.4 to 1.0	0.04 max.	....	....	0.2	0.3
No 9....	remainder	8.0 to 9.0	0.18	0.2 to 0.8	0.04 max.	....	....	0.2	0.3
No. 10....	remainder	....	0.90	....	0.04 max.	....	5.3 to 6.7	0.1	0.2
No. 11....	remainder	....	1.30	....	0.04 max.	....	....	0.1	0.2
No. 12....	remainder	9.4 to 10.6	0.13	....	0.04 max.	....	....	1.0	0.3

[a] Nickel, max., 0.02 per cent.

Sampling

4. The sample for chemical analysis may be taken by sawing, drilling, or milling and shall represent the average cross-section of the ingot. The tool shall be thoroughly cleaned and no lubricant shall be used in the sampling operation. The sample shall weigh not less than 50 g.

Rejection

5. Material which fails to conform to the requirements of these specifications may be rejected, and if rejected, the manufacturer's responsibility shall be limited to replacing the rejected material without charge to the purchaser. The full weight of the rejected material shall be returned to the manufacturer.

TENTATIVE SPECIFICATIONS

FOR

MAGNESIUM-BASE ALLOY SAND CASTINGS[1]

A.S.T.M. Designation: B 80 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to **annual revision.** Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1930; REVISED, 1931, 1934, 1936.

By publication of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing the specifications against liability for infringement of Letters Patent nor assume any such liability, and such publication should not be construed as a recommendation of any patented or proprietary application that may be involved.

Scope

1. These specifications cover commercial magnesium-base alloy sand castings having a specific gravity of 1.9 or less. Five alloys are specified and are designated Alloys Nos. 1, 2, 3, 4, and 5 (see Explanatory Note 1).

Manufacture

2. (*a*) The alloys may be made from virgin metal or from purified scrap metal of known composition.

(*b*) Castings made from Alloys Nos. 1,2,3, and 4 may be subjected to such heat treatment as the manufacturer desires to produce material that will conform to the requirements specified. Heat treatment shall be performed on the whole of a casting, never on a part only, and shall be applied in a manner that will produce the utmost uniformity.

Chemical Composition

3. The castings shall conform to the following requirements as to chemical composition:

Alloy	Magnesium, per cent	Aluminum, per cent	Manganese, min., per cent	Zinc, per cent	Copper, per cent	Cadmium, per cent	Silicon, max., per cent	Other Impurities,[a] max., per cent
No. 1............	remainder	7.8 to 9.2	0.15	0.3 max.	0.05 max.	....	0.5	0.3
No. 2............	remainder	9.0 to 11.0	0.10	0.3 max.	0.05 max.	....	0.5	0.3
No. 3............	remainder	11.2 to 12.8	0.10	0.3 max.	0.05 max.	....	0.5	0.3
No. 4............	remainder	5.3 to 6.7	0.15	2.5 to 3.5	0.05 max.	....	0.5	0.3
No. 5............	remainder	1.5 to 2.5	0.15	0.3 max.	3.0 to 5.0	1.5 to 2.5	0.5	0.3

[a] Nickel, max., 0.03 per cent.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-7 on Light Metals and Alloys, Cast and Wrought.

Sampling

4. The sample for chemical analysis may be taken by sawing, drilling, or milling the casting or tension test specimen and shall represent the average cross-section of the piece. The tool shall be thoroughly cleaned and no lubricant shall be used in the sampling operation. The sample shall weigh not less than 50 g.

Tension Tests

5. The tension test specimens representing the castings shall conform to the following requirements as to tensile properties:

ALLOY	CONDITION	TENSILE STRENGTH, MIN., LB. PER SQ. IN.	ELONGATION IN 2 IN., MIN., PER CENT
No. 1	As-cast	23 000	3
	Heat Treatment No. 1[a]	29 000	6
No. 2	Heat Treatment No. 1[a]	29 000	5
	Heat Treatment No. 2[b]	29 000	2
	Heat Treatment No. 3[c]	29 000	not required
No. 3	Heat Treatment No. 3[c]	27 000	not required
No. 4	As-cast	24 000	4
	Heat Treatment No. 1[a]	30 000	6
	Heat Treatment No. 3[c]	32 000	2
No. 5	As-cast	21 000	3

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[a] Heat Treatment No. 1—solution heat treatment.

[b] Heat Treatment No. 2—solution heat treatment plus partial aging.

[c] Heat Treatment No. 3—solution heat treatment plus complete aging.

Test Specimens

6. The tension test specimens shall be separately cast in green sand and shall be "cast to size" according to the dimensions shown in Fig. 1. If the castings are heat treated, the tension test specimens representing such castings shall be similarly heat treated. They shall not be machined prior to test except to adapt the grips to the holders of the testing machine in such a manner as to insure an axial load.

Number of Tests

7. (*a*) The tests shall be made, so far as possible, by heats or melts, but unless otherwise mutually agreed upon by the manufacturer and purchaser, two tension tests shall be made for each unit of 500 lb. or fraction thereof.

(*b*) If any tension test specimen is improperly machined or shows flaws upon testing, it may be discarded; in which case the manufacturer and the purchaser, or his representative, may agree upon the selection of another specimen in its stead.

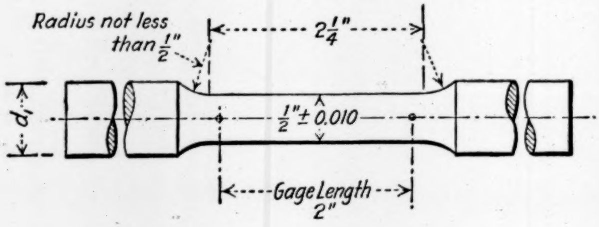
Workmanship and Finish

8. The castings shall be of uniform quality and condition, free from cracks or other injurious defects, and shall be well cleaned before inspection by sand-blasting or any other approved process.

Inspection

9. (*a*) Inspection may be made at the manufacturer's works where the castings are made, or at the point at which they are received, at the option of the purchaser.

(*b*) If the purchaser elects to have the inspection made at the manufacturer's works, the manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.



Note:

The Gage Lengtn, Parallel Section and Fillets shall be as shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a way, that the Load shall be Axial.

In Order to promote the Breaking of the Specimen in the Center it is permissible to use a Taper in the Reduced Section from the Fillets to the Center of not to exceed 0.010 in.

It is recommended, that Diameter d, be from 3/4" to 1."

FIG. 1.—Tension Test Specimen.

Rejection

10. Castings which show injurious defects revealed by machining operations subsequent to acceptance may be rejected and, if rejected, the manufacturer's responsibility shall be limited to replacing the rejected material without charge to the purchaser. The full weight of the original material rejected shall be returned to the manufacturer.

EXPLANATORY NOTES

NOTE 1. *Alloy No. 1.*—This alloy has a specific gravity of about 1.80. It has higher impact strength and elongation and lower yield strength than Alloy No. 2. It is used in the as-cast condition for castings subjected to moderate stresses and in the solution heat-treated condition (H. T. No. 1) for castings requiring maximum toughness and elongation. The copper and nickel contents should be kept low to minimize corrosion.

Alloy No. 2.—This alloy has a specific gravity of about 1.81. It is used both in the solution heat-treated condition (H. T. No. 1) and in the solution heat-treated and aged conditions (H. T. No. 2 and H. T. No. 3). Aging increases the yield strength and hardness and decreases the toughness and elongation. The copper and nickel contents should be kept low to minimize corrosion.

Alloy No. 3.—This alloy has a specific gravity of about 1.82. It is used in the solution heat-treated and aged condition (H. T. No. 3) for castings requiring the maximum obtainable yield strength. Toughness and elongation are low. The copper and nickel contents should be kept low to minimize corrosion.

Alloy No. 4.—This alloy has a specific gravity of about 1.84. It is used in the as-cast, the solution heat-treated (H.T. No. 1), and the solution heat-treated and aged (H.T. No. 3) conditions. Its properties are somewhat better and its resistance to salt-water corrosion is decidedly better than in the case of Alloys Nos. 1 to 3, inclusive. The copper and nickel contents should be kept low to minimize corrosion.

Alloy No. 5.—This alloy has a specific gravity of about 1.86. Its thermal conductivity is 50 to 75 per cent greater than that of Alloys Nos. 1 to 4, inclusive, and is recommended where this property is of importance. It should not be used for other purposes because of its relatively poor corrosion resistance.

NOTE 2.—The yield strength of magnesium-base alloys is defined as the stress at which the stress-strain curve deviates 0.2 per cent from the modulus line. It may be determined by the "Offset Method" or the "Approximate Method Without the Stress-strain Diagram" (the latter is often referred to as the "Extension Under Load Method") as described in the Standard Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8) of the American Society for Testing Materials.[1]

The following data give typical yield strength values for the various alloys, together with the corresponding unit deformations for use with the "Approximate Method" based on a modulus of elasticity, $E = 6,500,000$ lb. per sq. in.:

ALLOY	CONDITION	TYPICAL YIELD STRENGTH (SET = 0.2 PER CENT), LB. PER SQ. IN.	UNIT DEFORMATION, INCH PER INCH OF GAGE LENGTH
No. 1	As-cast	11 000	0.0037
	Heat Treatment No. 1[a]	11 000	0.0037
No. 2	Heat Treatment No. 1[a]	12 000	0.0038
	Heat Treatment No. 2[b]	16 000	0.0045
	Heat Treatment No. 3[c]	19 000	0.0049
No. 3	Heat Treatment No. 3[c]	21 000	0.0052
No. 4	As-cast	11 000	0.0037
	Heat Treatment No. 1[a]	11 000	0.0074
	Heat Treatment No. 3[c]	19 000	0.0098
No. 5	As-cast	8 000	0.0032

[a] Heat Treatment No. 1—solution heat treatment.

[b] Heat Treatment No. 2—solution heat treatment plus partial aging.

[c] Heat Treatment No. 3—solution heat treatment plus complete aging.

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[1] 1936 Book of A.S.T.M. Standards, Part I, p. 833.

TENTATIVE SPECIFICATIONS
FOR
MAGNESIUM-BASE ALLOY SHEET[1]

A.S.T.M. Designation: B 90 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1932; Revised, 1934, 1936.

By publication of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing the specifications against liability for infringement of Letters Patent nor assume any such liability, and such publication should not be construed as a recommendation of any patented or proprietary application that may be involved.

Scope

1. These specifications cover commercial magnesium-base alloy sheet having a specific gravity of 1.8 or less. Two alloys are specified and are designated Alloys Nos. 6 and 11 (see Explanatory Note 1).

Manufacture

2. The alloys may be made from virgin metal or from purified scrap metal of known composition.

Chemical Composition

3. The sheet shall conform to the following requirements as to chemical composition:

Alloy	Magnesium, per cent	Aluminum, per cent	Manganese, min., per cent	Copper, max., per cent	Zinc, max., per cent	Silicon, max., per cent	Other Impurities,[a] max., per cent
No. 6..........	remainder	3.3 to 4.7	0.20	0.05	0.3	0.5	0.3
No. 11..........	remainder	....	1.20	0.05	....	0.3	0.3

[a] Nickel, max., 0.03 per cent.

Sampling

4. The sample for chemical analysis may be taken by sawing, shearing, or machining and shall represent the average cross-section of the sheet. The tool shall be thoroughly cleaned and no lubricant

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-7 on Light Metals and Alloys, Cast and Wrought.

shall be used in the sampling operation. The sample shall weigh not less than 50 g.

Tension Tests

5. The sheet shall conform to the following requirements as to tensile properties:

ALLOY	CONDITION	TENSILE STRENGTH, LB. PER SQ. IN.	YIELD STRENGTH[a] (SET = 0.2 PER CENT), MIN., LB. PER SQ. IN.	ELONGATION IN 2 IN., MIN., PER CENT
No. 6....	Hard Rolled (H).....	36 000 min.	25 000	4
	Annealed (A).........	38 000 max.	......	10
No. 11....	Heat Treated (T)....	35 000 max.	......	12
	Heat Treated and Rolled (TR).......	32 000 min.	24 000	4

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[a] See Explanatory Note 2.

Test Specimens

6. The tension test specimens may be cut in any direction irrespective of the direction of rolling and shall be machined to the form and dimensions shown in Fig. 1.

Number of Tests

7. Two tension test specimens shall be taken to represent each 500 lb. or fraction thereof, or such other quantities as may be mutually agreed upon between the manufacturer and purchaser.

Permissible Variations in Dimensions

8. *Thickness Tolerances.*—The thickness of sheets shall not vary from that specified by more than the following permissible variations:

	PERMISSIBLE VARIATIONS IN THICKNESS	
THICKNESS, IN.	SHEET UNDER 36 IN. IN WIDTH	SHEET 36 TO 50 IN. IN WIDTH
0.015 to 0.036............................	± 0.002 in.	± 0.0025 in.
0.037 to 0.050............................	± 0.0025 in.	± 0.003 in.
0.051 to 0.080............................	± 0.003 in.	± 0.004 in.
0.081 to 0.250............................	± 5 per cent of thickness	± 5 per cent of thickness

9. *Width Tolerances.*—The width of sheets shall not vary from that specified by more than the following permissible variations:

	PERMISSIBLE VARIATIONS IN WIDTH, IN.		
THICKNESS, IN.	SHEET 18 IN. AND UNDER IN WIDTH	SHEET OVER 18 TO 36 IN., INCL., IN WIDTH	SHEET 36 TO 50 IN. IN WIDTH
0.015 to 0.102.................	$\pm \frac{1}{16}$	$\pm \frac{3}{32}$	$\pm \frac{1}{8}$
0.103 to 0.250.................	$\pm \frac{3}{32}$	$\pm \frac{1}{8}$	$\pm \frac{3}{16}$

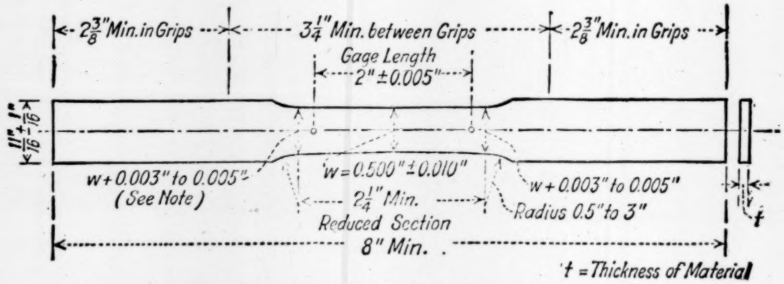
10. *Length Tolerances.*—(*a*) The length of sheets shall not vary from that specified by more than the following permissible variations:

	PERMISSIBLE VARIATIONS IN LENGTH, IN.			
THICKNESS, IN.	SHEET 18 IN. AND UNDER IN LENGTH	SHEET OVER 18 TO 48 IN., INCL., IN LENGTH	SHEET OVER 48 TO 120 IN., INCL., IN LENGTH	SHEET OVER 120 IN. IN LENGTH
0.015 to 0.250.....	$\pm \frac{1}{16}$	$\pm \frac{3}{32}$	$\pm \frac{1}{8}$	$\pm \frac{5}{32}$

(*b*) In case an exact length is specified, the permissible variation in length shall be $+\frac{1}{8}$ in. with no under tolerance.

Workmanship and Finish

11. All sheet shall be commercially flat and free from buckles, shall be free from injurious surface defects, and shall have a workmanlike finish.



Note: Gradual Taper from Ends of Reduced Section to Middle.
All Machining Dimensions are Shown below and Testing Dimensions above Specimen.

The ends shall be symmetrical within 0.01 in.

FIG. 1.—Standard Tension Test Specimen for Sheet Metals.

Inspection

12. (*a*) Inspection may be made at the manufacturer's works where the material is made, or at the point at which it is received, at the option of the purchaser.

(*b*) If the purchaser elects to have the inspection made at the manufacturer's works, the manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection

13. Material which fails to meet these specifications may be rejected, and if rejected, the manufacturer's responsibility shall be limited to replacing the rejected material without charge to the purchaser. The full weight of the rejected material shall be returned to the manufacturer.

EXPLANATORY NOTES

NOTE 1. *Alloy No. 6.*—This alloy has a specific gravity of about 1.77. Its physical properties and forming characteristics are superior to those of Alloy No. 11. The copper and nickel contents should be kept low to minimize corrosion.

Alloy No. 11.—This alloy has a specific gravity of about 1.76. It is recommended where maximum resistance to salt-water corrosion is required. The copper and nickel contents should be kept low to minimize corrosion.

NOTE 2.—The yield strength of magnesium-base alloys is defined as the stress at which the stress-strain curve deviates 0.2 per cent from the modulus line. It may be determined by the "Offset Method" or the "Approximate Method Without the Stress-strain Diagram" (the latter is often referred to as the "Extension Under Load Method") as described in the Standard Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8) of the American Society for Testing Materials.[1]

The following unit deformations for use with the "Approximate Method" are based on a modulus of elasticity, $E = 6,500,000$ lb. per sq. in.:

ALLOY	YIELD STRENGTH (SET = 0.2 PER CENT), MIN., LB. PER SQ. IN.	UNIT DEFORMATION INCH PER INCH OF GAGE LENGTH
No. 6	25 000	0.0058
No. 11	24 000	0.0057

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[1] 1936 Book of A.S.T.M. Standards, Part I, p. 833.

TENTATIVE SPECIFICATIONS
FOR
MAGNESIUM-BASE ALLOY FORGINGS[1]

A.S.T.M. Designation: B 91 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1932; REVISED, 1934, 1936.

By publication of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing the specifications against liability for infringement of Letters Patent nor assume any such liability, and such publication should not be construed as a recommendation of any patented or proprietary application that may be involved.

Scope

1. These specifications cover fully-worked (see Explanatory Note 1) commercial magnesium-base alloy forgings having a specific gravity of 1.9 or less. Six alloys are specified and are designated Alloys Nos. 1, 6, 7, 8, 9, and 10 (see Explanatory Note 2).

Manufacture

2. The alloys may be made from virgin metal or from purified scrap metal of known composition.

Chemical Composition

3. The forgings shall conform to the following requirements as to chemical composition:

Alloy	Magnesium, per cent	Aluminum, per cent	Manganese, min., per cent	Zinc, per cent	Copper, max., per cent	Tin, per cent	Silicon, max., per cent	Other Impurities,[a] max., per cent
No. 1.........	remainder	7.8 to 9.2	0.15	0.3 max.	0.05	....	0.5	0.3
No. 6.........	remainder	3.3 to 4.7	0.20	0.3 max.	0.05	....	0.5	0.3
No. 7.........	remainder	5.8 to 7.2	0.15	0.3 max.	0.05	....	0.5	0.3
No. 8.........	remainder	5.8 to 7.2	0.15	0.4 to 1.0	0.05	....	0.5	0.3
No. 9.........	remainder	7.8 to 9.2	0.15	0.2 to 0.8	0.05	....	0.5	0.3
No. 10.........	remainder	....	0.80	......	0.05	5.0 to 7.0	0.5	0.3

[a] Nickel, max., 0.03 per cent.

Sampling

4. The sample for chemical analysis may be taken by sawing, drilling, or milling and shall represent the average cross-section of the piece. The tool shall be thoroughly cleaned and no lubricant shall be used in the sampling operation. The sample shall weigh not less than 50 g.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-7 on Light Metals and Alloys, Cast and Wrought.

Tension Tests

5. The forgings shall conform to the following requirements as to tensile properties:

ALLOY	TENSILE STRENGTH, MIN., LB. PER SQ. IN.	YIELD STRENGTH[a] (SET = 0.2 PER CENT), MIN., LB. PER SQ. IN.	ELONGATION IN 2 IN., MIN., PER CENT
No. 1	42 000	24 000	5.0
No. 6	34 000	19 000	6.0
No. 7	34 000	19 000	6.0
No. 8	38 000	22 000	6.0
No. 9	42 000	24 000	5.0
No. 10	33 000	18 000	5.0

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[a] See Explanatory Note 3.

Test Specimens

6. Tension test specimens shall be taken in such a manner that the longitudinal axis of the specimen is parallel to the direction of the maximum flow of the metal in the forging and where practicable shall be taken from a full-size prolongation of the forging. The specimen may be machined to the form and dimensions shown in Fig. 1, or in the case of thin material may be machined to the form and dimensions shown in Fig. 2, or may be the full section of the material.

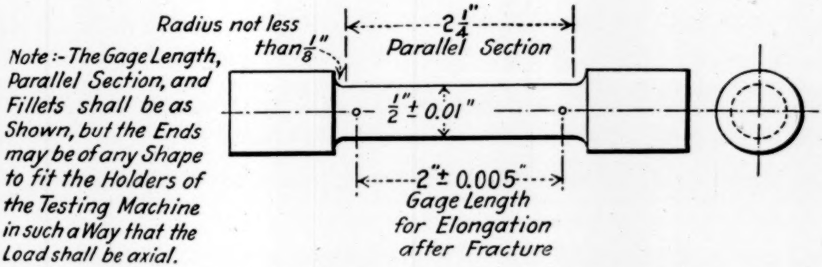

Radius not less than 1/8"
2 1/4"
Parallel Section
Note :- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.
1/2" ± 0.01"
2" ± 0.005"
Gage Length for Elongation after Fracture

FIG. 1.—Standard 2-in. Gage Length Tension Test Specimen.

Number of Tests

7. Two tension test specimens shall be taken to represent each 500 lb. or fraction thereof, or such other quantities as may be mutually agreed upon between the manufacturer and purchaser.

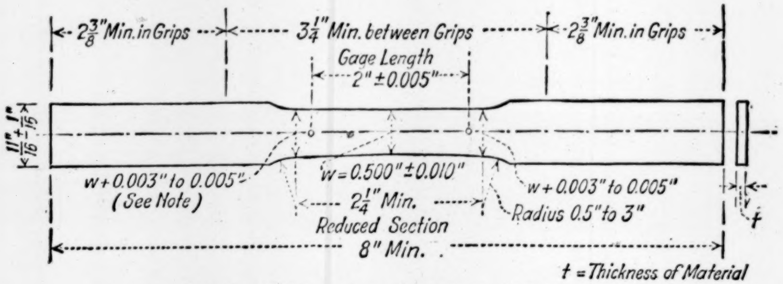
Workmanship and Finish

8. All material shall be of uniform quality, free from injurious surface defects and shall have a workmanlike finish.

Inspection

9. (*a*) Inspection may be made at the manufacturer's works where the material is made, or at the point at which it is received, at the option of the purchaser.

(*b*) If the purchaser elects to have the inspection made at the manufacturer's works, the manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.


2$\frac{3}{8}$" Min. in Grips
3$\frac{1}{4}$" Min. between Grips
2$\frac{3}{8}$" Min. in Grips
Gage Length
2" ± 0.005"
$\frac{11}{16}$" ± $\frac{1}{16}$"
w + 0.003" to 0.005"
(See Note)
w = 0.500" ± 0.010"
w + 0.003" to 0.005"
2$\frac{1}{4}$" Min.
Reduced Section
Radius 0.5" to 3"
t
8" Min.
t = Thickness of Material

Note: Gradual Taper from Ends of Reduced Section to Middle.

All Machining Dimensions are Shown below and Testing Dimensions above Specimen.

The ends shall be symmetrical within 0.01 in.

FIG. 2.—Standard Tension Test Specimen for Sheet Metals.

Rejection

10. Material which fails to meet these specifications may be rejected, and if rejected, the manufacturer's responsibility shall be limited to replacing the rejected material without charge to the purchaser. The full weight of the rejected material shall be returned to the manufacturer.

EXPLANATORY NOTES

NOTE 1.—The expression "fully worked" refers to material that has been worked sufficiently during the forging operations to develop maximum properties. Material that has been given smaller amounts of working will have correspondingly lower properties. Forging operations develop the maximum properties without the necessity of subsequent heat treatment.

NOTE 2. *Alloy No. 1.*—This alloy has a specific gravity of about 1.80. It can be readily fabricated under a press but cannot be hammer forged. It is stronger than Alloys Nos. 6, 7, 8, and 10 and has about the same mechanical properties as Alloy No. 9. It is sometimes used instead of Alloy No. 9 because it is less susceptible to cracking at elevated temperatures (hot shortness) during fabrication. Its resistance to corrosion is about the same as that of Alloy No. 9.

Alloy No. 6.—This alloy has a specific gravity of about 1.77. It is used for hot-press forgings and for hammer forgings of simple design. The forgeability of this alloy is superior to that of Alloys Nos. 7, 8, and 9, but its physical properties average somewhat lower. The copper and nickel contents should be kept low to minimize corrosion.

Alloy No. 7.—This alloy has a specific gravity of about 1.79. It is used for hot-press forgings. It is quite similar to Alloy No. 6, but is somewhat more difficult to forge and its properties average slightly higher. The copper and nickel contents should be kept low to minimize corrosion.

Alloy No. 8.—This alloy has a specific gravity of about 1.81. It is used for hot-press forgings. The properties of this alloy average somewhat higher than Alloys Nos. 6 and 7, and its resistance to salt-water corrosion is somewhat better than Alloys Nos. 6, 7, and 9. The copper and nickel contents should be kept low to minimize corrosion.

Alloy No. 9.—This alloy has a specific gravity of about 1.83. It is used for hot-press forgings of simple design requiring maximum properties. It has lower forgeability than the other alloys specified. The copper and nickel contents should be kept low to minimize corrosion.

Alloy No. 10.—This alloy has a specific gravity of about 1.85. It is used for hot-hammer forgings for moderately stressed parts. Resistance to salt-water corrosion is distinctly superior to that of the other alloys specified. The copper and nickel contents should be kept low to minimize corrosion.

NOTE 3.—The yield strength of magnesium-base alloys is defined as the stress at which the stress-strain curve deviates 0.2 per cent from the modulus line. It may be determined by the "Offset Method" or the "Approximate Method Without the Stress-strain Diagram" (the latter is often referred to as the "Extension Under Load Method") as described in the Standard Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8) of the American Society for Testing Materials.[1]

The following unit deformations for use with the "Approximate Method" are based on a modulus of elasticity, $E = 6{,}500{,}000$ lb. per sq. in.:

ALLOY	YIELD STRENGTH (SET = 0.2 PER CENT), MIN., LB. PER SQ. IN.	UNIT DEFORMATION, INCH PER INCH OF GAGE LENGTH
No. 1	24 000	0.0057
No. 6	19 000	0.0049
No. 7	19 000	0.0049
No. 8	22 000	0.0054
No. 9	24 000	0.0057
No. 10	18 000	0.0048

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[1] 1936 Book of A.S.T.M. Standards, Part I, p. 833.

TENTATIVE SPECIFICATIONS
FOR
MAGNESIUM-BASE ALLOY BARS, RODS AND SHAPES[1]

A.S.T.M. Designation: B 107 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1936.

By publication of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing the specifications against liability for infringement of Letters Patent nor assume any such liability, and such publication should not be construed as a recommendation of any patented or proprietary application that may be involved.

Scope

1. These specifications cover commercial magnesium-base alloy extruded bars, rods, and shapes. Four alloys are specified and are designated Alloys Nos. 6, 8, 9 and 11 (see Explanatory Note 1).

Manufacture

2. The alloys may be made from virgin metal or from purified scrap metal of known composition.

Chemical Composition

3. The bars, rods and shapes shall conform to the following requirements as to chemical composition:

Alloy	Magnesium, per cent	Aluminum, per cent	Manganese, min., per cent	Zinc, per cent	Copper, max., per cent	Silicon, max., per cent	Other Impurities,[a] max., per cent
No. 6	remainder	3.3 to 4.7	0.20	0.3 max.	0.05	0.5	0.3
No. 8	remainder	5.8 to 7.2	0.15	0.4 to 1.0	0.05	0.5	0.3
No. 9	remainder	7.8 to 9.2	0.15	0.2 to 0.8	0.05	0.5	0.3
No. 11	remainder	....	1.20	....	0.05	0.3	0.3

[a] Nickel, max., 0.03 per cent.

Sampling

4. The sample for chemical analysis may be taken by sawing, drilling, or milling and shall represent the average cross-section of the piece. The tool shall be thoroughly cleaned and no lubricant shall be used in the sampling operation. The sample shall weigh not less than 50 g.

Tension Tests

5. The material shall conform to the following requirements as to tensile properties:

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-7 on Light Metals and Alloys, Cast and Wrought.

ALLOY	SHAPE AND SIZE	TENSILE STRENGTH, MIN., LB. PER SQ. IN.	YIELD STRENGTH[a] (SET = 0.2 PER CENT), MIN., LB. PER SQ. IN.	ELONGATION IN 2 IN., MIN., PER CENT
No. 6	Round and Square up to 1½ in.	37 000	25 000	12
	Structural Shapes	34 000	17 000	10
No. 8	Round and Square up to 1½ in.	40 000	26 000	12
	Structural Shapes	38 000	23 000	10
No. 9	Round and Square up to 1½ in.	43 000	28 000	9
	Structural Shapes	40 000	25 000	8
No. 11	Round and Square up to 1½ in.	32 000	20 000	3

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[a] See Explanatory Note 2.

Test Specimens

6. Tension test specimens shall be taken in such a manner that the longitudinal axis of the specimen is parallel to the direction of maximum flow of the metal. The specimen may be machined to the form and dimensions shown in Fig. 1, or in the case of thin material may be machined to the form and dimensions shown in Fig. 2, or may be the full section of the material.

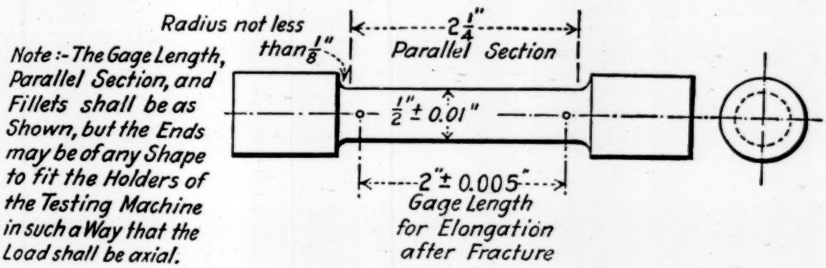

Radius not less than $\frac{1}{8}$"
$2\frac{1}{4}$"
Parallel Section
Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.
$\frac{1}{2}$" ± 0.01"
2" ± 0.005"
Gage Length for Elongation after Fracture

FIG. 1.—Standard 2-in. Gage Length Tension Test Specimen.

Number of Tests

7. Two tension test specimens shall be taken to represent each 500 lb. or fraction thereof, or such other quantities as may be mutually agreed upon between the manufacturer and purchaser.

Permissible Variations in Dimensions

8. Variations from the specified dimensions shall not exceed the following:

MATERIAL	DIAMETER OR DISTANCE ACROSS FLATS	PERMISSIBLE VARIATIONS, IN., PLUS OR MINUS
Round, Square, Hexagonal, and Rectangular Bars	Up to 0.500	0.007
	0.501 to 1.000	0.010
	1.001 to 2.000	0.012
	2.001 to 3.000	0.015
	3.001 and over	0.018

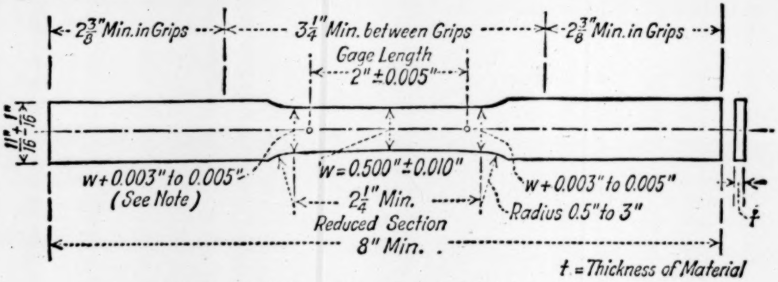
MATERIAL	DIAMETER OR DISTANCE ACROSS FLATS	PERMISSIBLE VARIATIONS, IN., PLUS OR MINUS
Structural Shapes	Up to 0.125	0.010
	0.126 to 0.500	0.015
	0.501 to 1.000	0.020
	0.001 to 2.000	0.025
	2.001 to 3.000	0.030
	3.001 to 4.000	0.035
	4.001 to 5.000	0.045
	5.001 and over	0.060

Workmanship and Finish

9. All material shall be of uniform quality, free from injurious surface defects and shall have a workmanlike finish.

Inspection

10. (*a*) Inspection may be made at the manufacturer's works where the material is made, or at the point at which it is received, at the option of the purchaser.



Note: Gradual Taper from Ends of Reduced Section to Middle.

All Machining Dimensions are Shown below and Testing Dimensions above Specimen.

The ends shall be symmetrical within 0.01 in.

FIG. 2.—Standard Tension Test Specimen for Sheet Metals.

(*b*) If the purchaser elects to have the inspection made at the manufacturer's works, the manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection

11. Material which fails to meet these specifications may be rejected, and if rejected, the manufacturer's responsibility shall be limited to replacing the rejected material without charge to the purchaser. The full weight of the rejected material shall be returned to the manufacturer.

EXPLANATORY NOTES

NOTE 1: *Alloy No. 6.*—This alloy has a specific gravity of about 1.77. It has been the standard alloy used in the production of most extruded material. The copper and nickel contents should be kept low to minimize corrosion.

Alloy No. 8.—This alloy has a specific gravity of about 1.80. It is superior to Alloy No. 6, both from the standpoint of mechanical properties and salt-water corrosion resistance and, hence, is rapidly replacing Alloy No. 6. The copper and nickel contents should be kept low to minimize corrosion.

Alloy No. 9.—This alloy has a specific gravity of about 1.81. Its properties are superior to those of Alloys Nos. 6 and 8 but it is more difficult to fabricate and, hence, is used primarily in the production of special shapes requiring maximum properties. The copper and nickel contents should be kept low to minimize corrosion.

Alloy No. 11.—This alloy has a specific gravity of about 1.76. It is recommended where maximum resistance to salt-water corrosion is required. Its properties are lower than those of the other magnesium alloys. The copper and nickel contents should be kept low to minimize corrosion.

NOTE 2.—The yield strength of magnesium-base alloys is defined as the stress at which the stress-strain curve deviates 0.2 per cent from the modulus line. It may be determined by the "Offset Method" or the "Approximate Method Without the Stress-strain Diagram" (the latter is often referred to as the "Extension Under Load Method") as described in the Standard Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8) of the American Society for Testing Materials.[1]

The following unit deformations for use with the "Approximate Method" are based on a modulus of elasticity, $E = 6,500,000$ lb. per sq. in.:

ALLOY	SHAPE AND SIZE	YIELD STRENGTH (SET = 0.2 PER CENT), MIN., LB. PER SQ. IN.	UNIT DEFORMATION, INCH PER INCH OF GAGE LENGTH
No. 6	Round and Square up to 1½ in.	25 000	0.0058
	Structural Shapes	17 000	0.0046
No. 8	Round and Square up to 1½ in.	26 000	0.0060
	Structural Shapes	23 000	0.0055
No. 9	Round and Square up to 1½ in.	28 000	0.0063
	Structural Shapes	25 000	0.0058
No. 11	Round and Square up to 1½ in.	23 000	0.0055

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[1] 1936 Book of A.S.T.M. Standards, Part I, p. 833.

TENTATIVE SPECIFICATIONS
FOR
BRONZE CASTINGS FOR TURNTABLES AND MOVABLE BRIDGES[1]

A.S.T.M. Designation: B 22 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED AS TENTATIVE, 1918; ADOPTED, 1921; REISSUED IN AMENDED FORM AS TENTATIVE, 1936.

Scope

1. (*a*) These specifications cover four classes of bronze castings for turntables and movable bridges. The particular class desired shall be specified in the order or agreed upon by the manufacturer and purchaser.

(*b*) The purposes for which these classes are ordinarily used are as follows:

Class A.—For contact with hardened steel disks at low speeds under pressures not over 3000 lb. per sq. in., for example, disk bearing metals used in turntables and center-bearing swing bridges.

Class B.—For contact with hardened steel disks at low speeds under pressures not over 2500 lb. per sq. in., for example, disk bearing metals used in turntable and center-bearing swing bridges and for contact with steel (tensile strength 60,000 lb. per sq. in., min.) at low speeds under pressures not over 1500 lb. per sq. in., for example, trunnions of movable bridges.

Class C.—For ordinary machinery bearings.

Class D.—For gears, worm wheels, nuts and similar parts which are subjected to other than compressive stresses.

Manufacture

2. (*a*) The bronze shall be a homogeneous alloy of copper and tin. The copper shall conform to the requirements of the Standard Specifications for Electrolytic Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars (A.S.T.M. Designation: B 5),[2] or the Standard Specifications for Lake Copper-Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars, "high-resistance" grade (A.S.T.M. Designation: B 4),[3] of the American Society for Testing Materials. The bronze shall be made from new metal,

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-5 on Copper and Copper Alloys, Cast and Wrought.

These tentative specifications are in effect a revision of, and replace the former Standard Specifications for Bronze Bearing Metals for Turntables and Movable Railroad Bridges (A.S.T.M. Designation: B 22 – 21), which standard was accordingly discontinued in 1936.

These specifications were prepared in cooperation with representatives of the American Association of State Highway Officials and the American Railway Engineering Association.

[2] 1936 Book of A.S.T.M. Standards, Part I, p. 531.

[3] *Ibid.*, p. 526.

except that scrap of known composition produced by the foundry at which the bronze is cast may be used.

(*b*) Care shall be exercised that the metal is not overheated and that the temperature at pouring and the conditions of cooling are such as will be most likely to secure dense castings.

Chemical Composition

3. The bronze shall conform to the following requirements as to chemical composition:[1]

ELEMENTS CONSIDERED	CLASS A	CLASS B	CLASS C	CLASS D
Copper, per cent	remainder	remainder	82 max.	89 max.
Tin, per cent	18 to 20	15 to 17	9 to 11	9 to 11
Lead, per cent	0.25 max.	0.25 max.	8 to 11	0.25 max.
Zinc, per cent	0.25 max.	0.25 max.	0.50 max.	1.75 to 2.25
Iron, max., per cent	0.25	0.25	0.25	0.25
Phosphorus, per cent	1.0 max.	1.0 max.	0.7 to 1.0	0.5 max.
Other impurities, max., per cent	0.5	0.5	0.5	0.5

Chemical Analyses

4. (*a*) An analysis of each melt may be made at the option of the purchaser. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.[1]

(*b*) The compression test coupon shall be used for analysis.

Methods of Analyses

5. Analyses, when made, shall be performed in accordance with the Tentative Methods of Chemical Analysis of Bronze Bearing Metal (A.S.T.M. Designation: B 46 - 36 T) of the American Society for Testing Materials.[2]

Compressive and Tensile Strengths

6. (*a*) The bronze shall conform to the following requirements as to compressive and tensile properties:

PROPERTIES CONSIDERED	CLASS A	CLASS B	CLASS C	CLASS D
COMPRESSION				
Deformation limit, min., lb. per sq. in.	24 000	18 000	....	....
Permanent set in 1 in. under 100 000 lb. per sq. in., in.	0.06 to 0.12	0.10 to 0.20	....	....
TENSION				
Tensile strength, min., lb. per sq. in.	....	....	....	33 000
Yield point, min., lb. per sq. in.	....	....	....	to be recorded
Elongation in 2 in., min., per cent	....	....	....	14

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[1] Material with a range of composition differing from that specified in Section 3, or containing elements not specified, may be used, provided the manufacturer shall submit in writing previous to the execution of the contract the range of composition of the material he proposes to use, and provided this range of composition shall be accepted by the purchaser.

[2] A.S.T.M. Methods of Chemical Analyses of Metals, 1936.

(*b*) The deformation limit in compression shall be determined as that load which produces a permanent set of 0.001 in. in the compression test specimen described in Section 6 (*b*).[1]

(*c*) The yield point in tension shall be determined as the stress producing an elongation under load of 0.5 per cent, that is, 0.01 in. in a gage length of 2 in.

Test Specimens

7. (*a*) A test bar of the form and dimensions shown in Fig. 1, to be used for the tension test specimen, and a suitable test bar for the compression test specimen, shall be an integral part of the casting, and shall be fed and cooled under the same conditions as the castings.

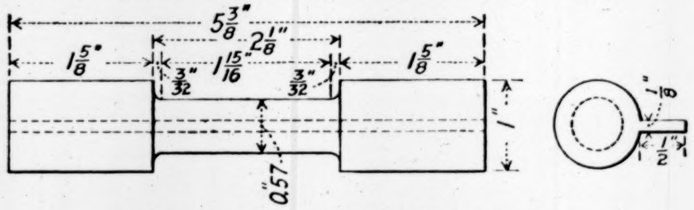
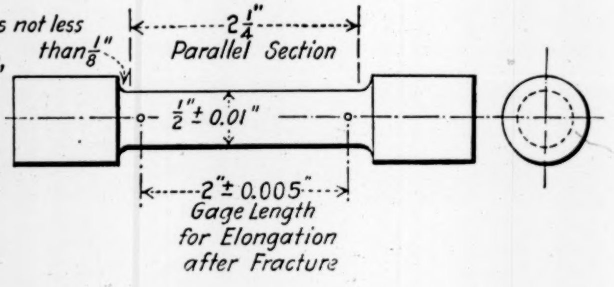


FIG. 1.—Test Bar for Tension Specimen.


Radius not less than 1/8"
2 1/4" Parallel Section
1/2" ± 0.01"
2" ± 0.005" Gage Length for Elongation after Fracture

Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 2.—Standard 2-in. Gage Length Tension Test Specimen.

(*b*) Compression test specimens shall be cylinders 1 sq. in. in cross-sectional area and 1 in. in height.[1]

(*c*) Tension test specimens, turned from the test bar shown in Fig. 1, shall conform to the dimensions shown in Fig. 2. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

Number of Tests

8. (*a*) One compression test shall be made from each melt for Class A and B castings; and one tension test from each melt for Class D castings.

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[1] The matters of revising the dimensions of compression test specimens and the method of determining the so-called "deformation limit" are under consideration by Committee E-1 on Methods of Testing. Tests are being made on cylindrical specimens 1 sq. in. in cross-sectional area and 3 in. in height. Committee B-5 on Copper and Copper Alloys, Cast and Wrought, which has written these specifications feels that these specifications with the present compression tests as specified may be satisfactorily used until better compression test specimens are available.—ED.

For castings of any grade weighing over 100 lb. finished, the specified tests shall be made for each casting.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded; in which case the manufacturer and the purchaser or his representative shall agree upon the selection of another specimen in its stead.

Finish

9. The castings shall be sound, clean, and free from blow-holes, porous places, cracks and other defects.

Inspection

10. (*a*) Inspection may be made at the manufacturer's works where the castings are made, or at the point at which they are received, at the option of the purchaser.

(*b*) If the purchaser elects to have inspection made at the manufacturer's works, the inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection

11. Castings which show injurious defects revealed by machining operations subsequent to acceptance may be rejected, and if rejected, shall be replaced by the manufacturer without charge to the purchaser. The full weight of the original material rejected shall be returned to the manufacturer.

ASSOCIATION OF AMERICAN RAILROADS
A.A.R. SPECIFICATION No.: M-503-34

TENTATIVE SPECIFICATIONS
FOR
BRONZE CASTINGS IN THE ROUGH FOR LOCOMOTIVE WEARING PARTS[1]

A.S.T.M. Designation: B 66 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued as Tentative, 1927; Adopted, 1928; Reissued in Amended Form as Tentative, 1936.

Scope

1. (*a*) These specifications cover four compositions of bronze castings in the rough for locomotive wearing parts. The particular composition desired shall be specified in the order or agreed upon by the manufacturer and purchaser.

(*b*) The purposes for which these compositions are ordinarily used are as follows:

Phosphor Bronze.—Shoes and wedges, floating rod bushings, or other uses where a hard wearing surface is required.

Hard Bronze.—General purpose wearing metal, may be cast in either sand or metal molds, for rod bushings, shoes and wedges, crosshead gibs, engine truck and trailer brasses.

Medium Bronze.—May be cast in sand or metal molds for driving box, engine and trailer truck brasses, hub liners, and bearings requiring lining metal for facing or lining.

Soft Bronze.—Generally cast in metal molds for driving boxes and special purposes where a soft metal is desired.

Chemical Composition

2. (*a*) The material shall conform to the following requirements as to chemical composition:

	Phosphor Bronze	Hard Bronze	Medium Bronze	Soft Bronze
Copper, per cent	remainder	remainder	remainder	remainder
Tin, per cent	9 to 11	7 to 10	6 to 8	4 to 6
Lead, per cent	9 to 11	10 to 15	14 to 22	23 to 27
Phosphorus, per cent	0.2 to 0.4	......	......	......
Zinc, max., per cent	0.5	1.25	1.25	0.75
Other impurities, max., per cent	1.0	0.75	0.75	0.75

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-5 on Copper and Copper Alloys, Cast and Wrought.

These tentative specifications are in effect a revision of, and replace the former Standard Specifications for Bronze Castings in the Rough for Locomotive Wearing Parts (A.S.T.M. Designation: B 66 – 28), which standard was accordingly discontinued in 1936.

(*b*) Where no requirements are prescribed for maximum impurity, these elements may be present up to any amount to come within the total impurity specified, provided the material otherwise meets the chemical and physical tests. Where maximum percentages are specified, the elements referred to are considered as impurities and shall not be intentionally added.

Chemical Analysis

3. An analysis shall be made by the purchaser or his representative from one casting representing each lot of 100 castings or fraction thereof. The chemical composition thus determined shall conform to the requirements specified in Section 2 (*a*) for the particular alloy.

Sample for Chemical Analysis

4. (*a*) The sample for chemical analysis shall be taken from the casting broken in the fracture test (Section 6) at three points along the fractured surface. Drillings through the skin shall be rejected. Equal quantity of drillings from each hole thoroughly mixed shall constitute the sample for chemical analysis.

(*b*) All samples shall be kept free of oil and shall be carefully treated with a magnet to remove any iron introduced in taking the sample.

Methods of Analyses

5. Analyses shall be made in accordance with the Tentative Methods of Chemical Analysis of Bronze Bearing Metal (A.S.T.M. Designation: B 46 – 36 T) of the American Society for Testing Materials.[1]

Examination of Fracture

6. (*a*) The casting representing a lot for acceptance shall be broken through the center and parallel with the longitudinal axis of the bearing in order to ascertain the uniformity of the grain of the metal. When this fracture shows separation or imperfect mixing of the component parts, or dross or dirt spots, the lot shall be rejected.

Number of Tests

7. One casting representing each lot of 100 castings or fraction thereof shall be taken for the fracture test.

Permissible Variations in Dimensions

8. The purchaser will furnish drawings showing the dimensions of the castings ordered and permissible variations therefrom, and all castings shall conform to the gages and dimensions shown on the drawings.

Workmanship and Finish

9. The castings shall be sound, free from blowholes, flaws and shrinkage cracks, and shall show good foundry practice and workmanship.

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[1] A.S.T.M. Methods of Chemical Analyses of Metals, 1936.

Marking

10. All castings shall have cast on them the manufacturer's initial or trade mark, the pattern number, and such other marks as are shown on the drawings. When serial numbers are specified, each lot of 100 castings or fraction thereof shall bear the same serial number, commencing with the numeral one at the beginning of the year and continuing consecutively until the end of the year, at each manufacturer's plant.

Inspection

11. (*a*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection at the place of manufacture shall be made prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

(*b*) The purchaser may make tests to govern the acceptance or rejection of the material in his own laboratory or elsewhere. Such tests shall be made at the expense of the purchaser.

Rejection

12. (*a*) Material represented by samples which fail to conform to the requirements of these specifications will be rejected.

(*b*) Material which, subsequent to test and inspection at the factory or elsewhere and its acceptance, shows injurious defects will be rejected and the manufacturer shall be notified.

Rehearing

13. Samples tested in accordance with these specifications, which represent rejected material, shall be preserved for 14 days from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

ASSOCIATION OF AMERICAN RAILROADS
A.A.R. SPECIFICATION No.: M-501-34

TENTATIVE SPECIFICATIONS
FOR
CAR AND TENDER JOURNAL BEARINGS, LINED[1]

A.S.T.M. Designation: B 67 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED AS TENTATIVE, 1927; ADOPTED, 1928; REISSUED IN AMENDED FORM AS TENTATIVE, 1936.

Scope

1. These specifications cover lined journal bearings for use on locomotive tenders, passenger and freight equipment cars.

Manufacture

2. (*a*) Before lining, the brass backs shall be bored and thoroughly tinned in accordance with the best standard practice. After lining, the ends of the bearings shall be made smooth by scraping, filing or machining. They shall not be ground or rubbed with abrasive materials.

(*b*) The purchaser reserves the right to inspect the brass backs after boring and previous to tinning and lining.

(*c*) Unless otherwise specified, bearings will be furnished with linings ¼ in. in thickness.

Chemical Composition of Backing

3. The backing metal shall conform to the following requirements as to chemical composition:

Copper		remainder
Lead, per cent		15 to 22
Tin, per cent		5 to 7
Impurities, max., per cent	including zinc	3
	excluding zinc	1

Chemical Composition of Lining

4. The lining metal shall conform to the following requirements as to chemical composition:

Tin, per cent	as specified
Antimony, min., per cent	8.0
Tin and antimony, per cent	10 to 14
Arsenic, max., per cent	0.2
Copper, max., per cent	0.5
Sum of tin, antimony, lead and aresenic, min., per cent	99.25
Other impurities, max., per cent	0.75

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-5 on Copper and Copper Alloys, Cast and Wrought.

These tentative specifications are in effect a revision of, and replace the former Standard Specifications for Car and Tender Journal Bearings, Lined (A.S.T.M. Designation: B 67 – 28), which standard was accordingly discontinued in 1936.

Samples for Chemical Analyses

5. The sample for chemical analysis of the backing shall consist of a thorough mixture of equal quantities of fine drillings taken at three points on the bearing, surface metal being discarded. The sample for analysis of the lining shall be taken by scraping the lining, after removing surface metal.

Methods of Chemical Analyses

6. (*a*) Analyses of the backing shall be made in accordance with the Tentative Methods of Chemical Analysis of Brass Ingots and Sand Castings (A.S.T.M. Designation: B 45 – 36 T) of the American Society for Testing Materials.[1]

(*b*) Analyses of the lining shall be made in accordance with the Tentative Methods of Chemical Analysis of Alloys of Lead, Tin, Antimony and Copper (A.S.T.M. Designation: B 18 – 36 T) of the American Society for Testing Materials.[1]

Examination of Fracture

7. The finished bearing representing a lot for acceptance shall be broken, either longitudinally or transversely, or both, in order to ascertain the uniformity of the grain of the metal. When this fracture shows separation or imperfect mixing of component parts, or dross or dirt spots, the lot shall be rejected.

Number of Tests

8. Bearings shall be divided into lots of 300 or fraction thereof, and one bearing shall be taken from each lot for purpose of tests, including chemical analyses.

Permissible Variations in Dimensions

9. (*a*) The purchaser shall furnish drawings showing the dimensions of the bearings ordered and permissible variations therefrom, and the bearings shall conform to these drawings within such permissible variations.

(*b*) The thickness at the center of the brass and of the complete bearing shall not vary more than $\frac{1}{32}$ in. over or under the normal thickness shown on the drawing. The thickness of the lining shall not vary more than $\frac{1}{32}$ in. over or under the normal thickness shown on the drawing.

Workmanship and Finish

10. The bearings shall be sound and free from blowholes, dross and mechanical defects. All bearing surfaces, including ends, before and after lining, shall be smooth finished and free from sand.

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[1] A.S.T.M. Methods of Chemical Analyses of Metals, 1936.

Marking

11. The name or initials of the manufacturer, the initials of the purchaser, size of journal bearing, pattern number and year cast shall be legibly cast with raised figures on a depressed surface of each bearing, as shown on the drawings. When a serial number is specified, each lot of 300 bearings or fraction thereof shall bear the same serial number, commencing with the numeral one at the beginning of the year and continuing consecutively until the end of the year, at each manufacturer's plant.

Inspection

12. (*a*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection at the place of manufacture shall be made prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

(*b*) The purchaser may make tests to govern the acceptance or rejection of the material in his own laboratory or elsewhere. Such tests shall be made at the expense of the purchaser.

Rejection

13. (*a*) Material represented by samples which fail to conform to the requirements of these specifications will be rejected.

(*b*) Material which, subsequent to test and inspection at the factory or elsewhere and its acceptance, shows injurious defects will be rejected and the manufacturer shall be notified.

Rehearing

14. Samples tested in accordance with these specifications, which represent rejected material, shall be preserved for 14 days from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS

FOR

SHEET AND STRIP PHOSPHOR BRONZE[1]

A.S.T.M. Designation: B 103 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1936.

Scope

1. (*a*) These specifications cover commercial sheet and slit-edged strip phosphor bronze commonly used for drawing, forming, stamping and bending, particularly in the making of spring devices for electrical apparatus. Sheet phosphor bronze shall be furnished in four grades described as Grades A, B, C and D.

(*b*) It should be understood that these specifications are general. Since phosphor bronze is used for many purposes where the requirements of the operations used are too particular to be specified by any of the ordinary physical tests, it is frequently advisable to submit samples or drawings to the manufacturer and secure an adjustment of anneal or temper to suit the actual operations to which the material is to be submitted.

Manufacture

2. (*a*) The bronze shall be a homogeneous alloy of copper and tin. The copper shall conform to the requirements of the Standard Specifications for Lake Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars (A.S.T.M. Designation: B 4),[2] or the Standard Specifications for Electrolytic Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars (A.S.T.M. Designation: B 5)[3] of the American Society for Testing Materials. The tin shall be equal to "Straits" or "Banca" in quality. Clean new scrap resulting from manufacturing operations upon material complying with these specifications or composed of material of equal purity may be employed. The phosphor copper and phosphor tin employed in manufacturing the phosphor bronze shall conform to the requirements of the Standard Specifications for Phosphor Copper (A.S.T.M. Designation:

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-5 on Copper and Copper Alloys, Cast and Wrought.

[2] 1936 Book of A.S.T.M. Standards, Part I, p. 526.

[3] *Ibid.*, p. 531.

B 52),[1] and the Standard Specifications for Phosphor Tin (A.S.T.M. Designation: B 51),[2] respectively, of the American Society for Testing Materials.

(*b*) The phosphor bronze shall be finished by the cold-rolling and annealing process and may be furnished in either the cold-rolled or annealed condition, as required.

Chemical Composition

3. The phosphor bronze shall conform to the following requirements as to chemical composition:

	GRADE A	GRADE C	GRADE D
Copper, per cent	remainder	remainder	remainder
Tin, per cent	3.80 to 5.80	7.0 to 9.0	9.0 to 11.0
Phosphorus, per cent	0.03 to 0.35	0.03 to 0.25	0.03 to 0.25
Iron, max., per cent	0.10	0.10	0.10
Lead, max., per cent	0.05	0.02	0.02
Antimony, max., per cent	0.01	0.01	0.01
Zinc, max., per cent	0.30	0.20	0.20
Nickel, max., per cent	....	0.15	....
Copper plus tin plus phosphorus, min., per cent	99.50	99.50	99.60

NOTE.—Grade B is reserved as the designation for the leaded phosphor bronze.

Chemical Analyses

4. (*a*) Analyses shall be made on each lot of 10,000 lb. of phosphor bronze or fraction thereof. Drillings, millings or clippings for analyses shall be taken from at least ten separate coils or pieces. Drillings or millings shall be taken on material thicker than 0.040 in. Clippings may be taken with shears from metal thinner than 0.040 in. Equal quantities shall be taken from each coil or piece selected for analysis and shall be thoroughly mixed together. Samples so prepared shall be divided into three equal parts, each of which shall be placed in a sealed package, one for the manufacturer, one for the purchaser, and one for an umpire, if necessary.

(*b*) In case of dissatisfaction, the metal shall be re-sampled in the presence of representatives of the manufacturer and purchaser. The thoroughly mixed sample shall be divided into three equal parts, each of which shall be placed in a sealed package, one for the manufacturer, one for the purchaser, and one for an umpire, if necessary.

Methods of Chemical Analyses

5. Analyses shall be made in accordance with the Tentative Methods of Chemical Analysis of Bronze Bearing Metal (A.S.T.M. Designation: B 46 – 36 T) of the American Society for Testing Materials.[3]

Tempers of Rolled Sheet

6. The temper of rolled sheet phosphor bronze shall be designated as shown in Table I.

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[1] 1936 Book of A.S.T.M. Standards, Part I, p. 720.

[2] *Ibid.*, p. 722.

[3] A.S.T.M. Methods of Chemical Analyses of Metals, 1936.

TABLE I.—TEMPER REQUIREMENTS FOR GRADES *A*, *C* AND *D* PHOSPHOR BRONZE SHEET.

Temper	Numbers Hard	Thickness, in.	Nominal Reduction by Rolling, per cent	Tensile Strength, lb. per sq. in.		Rockwell "B" Hardness ($\frac{1}{16}$-in. ball, 100-kg. load)		Rockwell "G" Hardness ($\frac{1}{16}$-in. ball, 150-kg. load)		Rockwell 30 "T" Hardness	
				min.	max.	min.	max.	min.	max.	min.	max.
						GRADE A PHOSPHOR BRONZE SHEET					
Soft..........	0.....	0.040 and over	0	40 000	55 000	7	50	..	12	..	..
		0.030 and over				...	...	..	..	24	50
		0.020 to 0.040				0	45	..	..	..	..
		0.010 to 0.030				...	...	..	..	16	46
Half-hard.....	2.....	0.040 and over	20.7	55 000	70 000	60	81	20	53	..	..
		0.030 and over				...	...	..	..	57	73
		0.020 to 0.040				53	78	15	51	..	..
		0.010 to 0.030				...	...	..	..	52	71
Hard....	4.....	0.040 and over	37.1	72 000	87 000	82	90	55	66	..	..
		0.030 and over				...	...	..	..	71	77
		0.020 to 0.040				80	88	53	64	..	..
		0.010 to 0.030				...	...	..	..	69	75
Extra-hard....	6.....	0.040 and over	50.0	84 000	98 500	88	94	64	73	..	..
		0.030 and over				...	...	..	..	75	80
		0.020 to 0.040				86	92	62	71	..	..
		0.010 to 0.030				...	...	..	..	73	78
Spring........	8.....	0.040 and over	60.4	91 000	105 000	90	96	69	75	..	..
		0.030 and over				...	..	..	..	77	81
		0.020 to 0.040				88	94	67	73	..	..
		0.010 to 0.030				...	...	..	..	75	79
Extra-spring...	10....	0.040 and over	68.6	96 000	109 000	92	97	72	77	..	..
		0.030 and over				...	...	..	..	78	82
		0.020 to 0.040				89	94	70	75	..	..
		0.010 to 0.030				...	...	..	..	76	80
						GRADE C PHOSPHOR BRONZE SHEET					
Soft..........	0.....	0.040 and over	0	53 000	67 000	29	70	..	33	..	..
		0.030 and over				...	...	..	..	38	68
		0.020 to 0.040				20	66	..	..	..	..
		0.010 to 0.030				...	...	..	..	27	62
Half-hard.....	2.....	0.040 and over	20.7	69 000	84 000	76	91	47	68	..	..
		0.030 and over				...	...	..	..	67	78
		0.020 to 0.040				69	88	40	64	..	..
		0.010 to 0.030				...	...	..	..	63	75
Hard.........	4.....	0.040 and over	37.1	85 000	100 000	91	97	69	77	..	..
		0.030 and over				...	..	..	..	76	81
		0.020 to 0.040				89	95	65	74	..	..
		0.010 to 0.030				...	...	..	..	73	80
Extra-hard....	6.....	0.040 and over	50.0	97 000	111 500	95	100	76	82	..	..
		0.030 and over				...	...	..	..	78	83
		0.020 to 0.040				93	98	73	79	..	..
		0.010 to 0.030				...	...	..	..	77	82
Spring........	8.....	0.040 and over	60.4	105 000	118 500	97	102	79	85	..	..
		0.030 and over				...	...	..	..	79	84
		0.020 to 0.040				95	100	76	82	..	..
		0.010 to 0.030				...	...	..	..	78	83
Extra-spring...	10.....	0.040 and over	68.6	109 500	122 000	98	103	81	86	..	..
		0.030 and over				...	...	..	..	80	84
		0.020 to 0.040				96	101	78	83	..	..
		0.010 to 0.030				...	...	..	..	79	83

TABLE I.—TEMPER REQUIREMENTS FOR GRADES *A*, *C* AND *D* PHOSPHOR BRONZE SHEET (*Continued*).

Temper	Numbers Hard	Thickness, in.	Nominal Reduction by Rolling, per cent	Tensile Strength, lb. per sq. in.		Rockwell "B" Hardness ($\frac{1}{16}$-in. ball, 100-kg. load)		Rockwell "G" Hardness ($\frac{1}{16}$-in. ball, 150-kg. load)		Rockwell 30 "T" Hardness	
				min.	max.	min.	max.	min.	max.	min.	max.
GRADE D PHOSPHOR BRONZE SHEET											
Soft..........	0.....	0.040 and over	0	58 000	73 000	35	75	..	40	..	..
		0.030 and over				...	...	..	..	40	78
		0.020 to 0.040				25	71	..	30	..	..
		0.010 to 0.030				...	...	..	..	29	64
Half-hard.....	2.....	0.040 and over	20.7	76 000	91 000	78	95	48	75	..	..
		0.030 and over				...	...	..	..	67	80
		0.020 to 0.040				74	93	38	71	..	..
		0.010 to 0.030				...	...	..	..	63	77
Hard.........	4.....	0.040 and over	37.1	94 000	109 000	94	101	72	83	..	..
		0.030 and over				...	...	..	..	78	82
		0.020 to 0.040				92	100	68	80	..	..
		0.010 to 0.030				...	...	..	..	75	81
Extra-hard....	6.....	0.040 and over	50.0	107 000	122 000	98	103	79	86	..	..
		0.030 and over				...	...	..	..	80	84
		0.020 to 0.040				97	102	76	83	..	..
		0.010 to 0.030				...	...	..	..	79	83
Spring........	8.....	0.040 and over	60.4	115 000	129 000	99	104	81	88	..	..
		0.030 and over				...	...	..	..	81	85
		0.020 to 0.040				98	103	78	85	..	..
		0.010 to 0.030				...	...	..	..	80	84
Extra-spring..	10.....	0.040 and over	68.6	120 000	133 000	100	105	83	90	..	..
		0.030 and over				...	...	..	..	82	86
		0.020 to 0.040				99	104	80	87	..	..
		0.010 to 0.030				...	...	..	..	81	85

Tempers of Annealed Sheet

7. Sheet phosphor bronze is not generally supplied in the annealed condition, therefore it is unnecessary to specify a number of anneals. The diameter of average grain of annealed sheet may be agreed upon by the manufacturer and purchaser, and the hardness and strength shall be kept within the limits prescribed in Table I.

Physical Properties

8. (*a*) *Tensile Strength.*—The tension test shall be standard for all tempers of rolled phosphor bronze and acceptance or rejection shall depend only on the tensile strength values specified in Table I. Ninety-five per cent of the tensile strength tests shall be within the specified limits, and only one tension test is allowable outside the limits, given in Table I.

(*b*) *Hardness.*—For convenience in testing, Rockwell hardness and Rockwell Superficial hardness test values are also given for some thicknesses. The Rockwell hardness values should be considered as approximate and informatory only.

Test Specimens

9. Test specimens shall be taken in such numbers and from such locations in each lot of material under test as to be representative of the quality, and not less than five specimens shall be taken from any lot.

TABLE II.—PERMISSIBLE VARIATIONS IN THICKNESS, PLUS AND MINUS, IN.

Thickness		Permissible Variations in Thickness, plus and minus, in.		
B. & S. Gage No.	Inch	Up to 8 in. in Width, inclusive	Over 8 to 14 in. in Width, inclusive	Over 14 to 20 in. in Width, inclusive
0000	0.4600	0.0058	0.0062	0.0069
000	0.4096	0.0055	0.0060	0.0066
00	0.3648	0.0054	0.0059	0.0064
0	0.3249	0.0053	0.0056	0.0061
1	0.2893	0.0050	0.0054	0.0060
2	0.2576	0.0049	0.0053	0.0058
3	0.2294	0.0048	0.0051	0.0056
4	0.2043	0.0046	0.0049	0.0054
5	0.1819	0.0044	0.0048	0.0053
6	0.1620	0.0043	0.0046	0.0051
7	0.1443	0.0041	0.0044	0.0049
8	0.1285	0.0040	0.0043	0.0048
9	0.1144	0.0038	0.0041	0.0046
10	0.1019	0.0036	0.0040	0.0044
11	0.0907	0.0035	0.0038	0.0043
12	0.0808	0.0034	0.0036	0.0041
13	0.0720	0.0031	0.0035	0.0040
14	0.0641	0.0030	0.0034	0.0038
15	0.0571	0.0029	0.0033	0.0036
16	0.0508	0.0028	0.0031	0.0035
17	0.0453	0.0026	0.0030	0.0034
18	0.0403	0.0025	0.0029	0.0033
19	0.0359	0.0023	0.0028	0.0031
20	0.0320	0.0021	0.0026	0.0030
21	0.0285	0.0020	0.0025	0.0029
22	0.0253	0.0019	0.0024	0.0028
23	0.0226	0.0018	0.0023	0.0026
24	0.0201	0.0016	0.0021	0.0025
25	0.0179	0.0015	0.0020	0.0024
26	0.0159	0.0014	0.0020	0.0024
27	0.0142	0.0013	0.0019	0.0023
28	0.0126	0.0011	0.0018	0.0021
29	0.0113	0.0010	0.0016	0.0020
30	0.0100	0.0009	0.0015	0.0019
31	0.0089	0.0008	0.0015	0.0019
32	0.0080	0.0008	0.0014	0.0018
33	0.0071	0.0006	0.0013	0.0016
34	0.0063	0.0006	0.0011	0.0016
35	0.0056	0.0005	0.0011	0.0015
36	0.0050	0.0005	0.0010	0.0014
37	0.0045	0.0005	0.0010	0.0014
38	0.0040	0.0004	0.0009	0.0013

Physical Tests

10. In making physical tests reference should be made to the following methods of test of the American Society for Testing Materials:

(*a*) *Tension Tests.*—Standard Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8).[1]

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[1] 1936 Book of A.S.T.M. Standards, Part I, p. 833.

(*b*) *Rockwell Hardness.*—Standard Methods of Rockwell Hardness Testing of Metallic Materials (A.S.T.M. Designation: E 18).[1]

Grain Size

11. Grain size shall be the standard test for sheet phosphor bronze of all thicknesses in annealed tempers. Grain size limits may be agreed upon by the manufacturer and purchaser, but in determining grain size, reference should be made to the Standard Rules Governing the Preparation of Micrographs of Metals and Alloys, Including Recommended Practice for Photography as Applied to Metallography (A.S.T.M. Designation: E 2) of the American Society for Testing Materials.[2]

Permissible Variation in Dimensions

12. (*a*) *Width.*—The width of phosphor bronze sheet and strip shall be within the following permissible variations:

	PERMISSIBLE VARIATIONS IN WIDTH, IN.			
THICKNESS, IN.	UP TO 2 IN. IN WIDTH, INCLUSIVE	OVER 2 TO 8 IN. IN WIDTH, INCLUSIVE	OVER 8 TO 14 IN. IN WIDTH, INCLUSIVE	OVER 14 TO 20 IN. IN WIDTH, INCLUSIVE
Over 0.004 up to and including 0.032	+0.010	+0.015	+0.020	+0.025
Over 0.032 up to and including 0.132	+0.020	+0.025	+0.030	+0.035

(*b*) All variations in width shall be over the specified width, unless otherwise designated by the purchaser.

13. *Thickness.*—The standard method of specifying thickness shall be in terms of Brown & Sharpe Gage. When the thickness is specified in either common or decimal fractions of an inch, the tolerances shall be those of the corresponding group of Brown & Sharpe gages shown in Table II.

14. *Length.*—Metal may be furnished in coils or flat strips as required. Coils shall consist of not more than three lengths, no one of which shall be less than 10 ft. in length. When furnished in flat strips tolerances for metal cut to length shall be plus 0.250 in., minus 0.000 in. All variations in length shall be *over* the specified length, unless otherwise designated by the purchaser.

15. (*a*) *Acceptable Short Lengths.*—Flat strip lengths shall be in accordance with the following regular practice:

When ordered in lengths over 10 up to 12 ft.	40 per cent may be 10 ft. and over. 30 per cent may be 8 to 10 ft. 20 per cent may be 6 to 8 ft. 10 per cent may be 4 to 6 ft. Not more than 40 per cent of any one shipment may be less than the length ordered.
When ordered in 10-ft. lengths	40 per cent may be 8 ft. and over. 30 per cent may be 6 to 8 ft. 20 per cent may be 4 to 6 ft. 10 per cent may be 2 to 4 ft. Not more than 40 per cent of any one shipment may be less than 10 ft.

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[1] 1936 Book of A.S.T.M. Standards, Part I, p. 824.

[2] *Ibid.*, p. 763.

When ordered in 8-ft. lengths	30 per cent may be 6 ft. and over. 20 per cent may be 4 to 6 ft. 10 per cent may be 2 to 4 ft. Not more than 30 per cent of any one shipment may be less than 8 ft.
When ordered in 6-ft. lengths	20 per cent may be 4 ft. and over. 10 per cent may be 2 to 4 ft. Not more than 20 per cent of any one shipment may be less than 6 ft.

(*b*) When special lengths are required, they shall be specified in the order.

16. *Straightness.*—The edgewise curvature in a 72-in. length of metal shall not exceed the following:

When shipped as strip	½ in.
When shipped in coils	1 in.

Finish

17. The phosphor bronze shall be free from injurious external and internal defects of a nature which will interfere with the purpose for which it is intended. It shall be well cleaned and free from dirt.

Inspection

18. The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

Rejection

19. Material which fails to conform to these specifications will be rejected and the manufacturer shall be notified.

TENTATIVE SPECIFICATIONS
FOR
SEAMLESS COPPER-NICKEL ALLOY CONDENSER TUBES AND FERRULE STOCK[1]

A.S.T.M. Designation: B 104 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1936.

Scope

1. These specifications cover two grades of copper-nickel alloy seamless tubes and ferrule stock for condenser use.

Process

2. The tubes shall be cold drawn to size from an alloy made from lake or electrolytic copper, conforming to the requirements of either the Standard Specifications for Lake Copper Wire Bars, Cakes, Slabs, Billets Ingots and Ingot Bars (A.S.T.M. Designation: B 4)[2] or the Standard Specifications for Electrolytic Copper Wire Bars, Cakes, Slabs, Billets Ingots and Ingot Bars (A.S.T.M. Designation: B 5)[3] of the American Society for Testing Materials, and nickel of electrolytic grade conforming to the requirements of the Standard Specifications for Nickel (A.S.T.M. Designation: B 39) of the American Society for Testing Materials.[4] Zinc, if present in the alloy, shall be of No. 1 high grade conforming to the Standard Specifications for Slab Zinc (Spelter) (A.S.T.M. Designation: B 6) of the American Society for Testing Materials.[5] Tin, if present in the alloy, shall be "Straits" tin or its equivalent. Scrap shall not be used, except such as may result from the manufacture of articles of the same composition.

Annealing

3. Tubes and ferrule stock shall be annealed sufficiently to enable the tubes to pass the metallographic and physical tests herein specified, excepting that ferrule stock shall not be subjected to the hammering and expanding tests specified in Sections 7 and 8, respectively.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-5 on Copper and Copper Alloys, Cast and Wrought.

[2] 1936 Book of A.S.T.M. Standards, Part I, p. 526.

[3] *Ibid.*, p. 531.

[4] *Ibid.*, p. 684.

[5] *Ibid.*, p. 714.

Chemical Composition

4. The material shall conform to the following requirements as to chemical composition:

	GRADE A	GRADE B
Copper, per cent	remainder	remainder
Nickel, min., per cent	29.0	19.0
Manganese, max., per cent	1.0	1.0
Tin, max., per cent	1.5	1.0
Zinc, max., per cent	1.0	6.0
Iron, max., per cent	0.5	0.5
Lead, max., per cent	0.05	0.05

Sample for Chemical Analysis

5. The sample for chemical analysis shall consist of drillings, millings, or clippings taken from at least three separate tubes from each lot of 600 tubes or less, equal quantities being taken from each tube and thoroughly mixed. Samples so prepared shall be divided into three equal parts, each of which shall be placed in a sealed package, one for the manufacturer one for the purchaser, and one for an umpire, if necessary.

Microscopic Examination

6. The tubes shall be so annealed that, when magnified to 75 diameters, a properly prepared specimen shall show uniform and complete recrystallization.

Hammering Test

7. The tubes selected for test shall be capable of standing the following test without showing cracks or flaws: Pieces cut from the ends of the tubes shall be hammered flat on different elements throughout their length so that a gage set at three times the thickness of the metal shall pass over the tube freely throughout the flattened part, except at such points where changes in the elements of flattening take place.

Expanding Test

8. The tubes selected for test shall be capable of standing the following test without showing signs of cracking or rupture: A pin having a taper of 1½ in. per ft. shall be driven into the tube until the inside diameter has been increased 30 per cent.

Hydrostatic Test

9. Each tube shall stand an internal hydrostatic pressure of 1000 lb. per sq. in. without leakage, and shall show no sign of strain or cracking.

Number of Tests

10. Tubes shall be grouped into lots of 600 tubes or fraction thereof. Three tubes shall be selected from each lot and subjected to the physical tests specified in Sections 6 to 8, inclusive.

Permissible Variations in Dimensions and Weight

11. *Diameter.*—The outside diameter of the tubes shall not vary from that specified by more than the following amounts, as measured by "go" and "not go" ring gages:

NOMINAL DIAMETER, IN.	PERMISSIBLE VARIATION, IN.
Up to 0.500, incl	±0.003
Over 0.500 to 0.740, incl	±0.0035
Over 0.740 to 1.000, incl	±0.004
Over 1.000 to 1.250, incl	±0.0045
Over 1.250 to 1.500, incl	±0.005

12. *Thickness.*—No tube at its thinnest point shall be less than the thickness specified.

13. *Length.*—The length shall not be less than that ordered when measured at a temperature of 20 C. (68 F.), but may be more than that ordered by the amounts in the following table:

ORDERED LENGTH, FT.	PERMISSIBLE VARIATION, IN.
Up to 15, incl	$+\frac{1}{16}$
Over 15 to 20, incl	$+\frac{3}{32}$
Over 20	$+\frac{1}{8}$

14. *Weights.*—No single tube that exceeds the calculated weight by more than 7.0 per cent will be accepted. One cubic inch of the material is assumed to weigh 0.323 lb. (Note).

NOTE.—One cubic inch of the copper-nickel alloy containing more than 4.0 per cent zinc shall be assumed to weigh 0.320 lb., and the alloy containing less than 4.0 per cent zinc shall be assumed to weigh 0.323 lb.

Workmanship

15. The tubes shall be round, straight and of uniform thickness throughout. They shall be free from cracks, seams, slivers, scale and other surface defects both inside and outside.

Finish

16. All tubes shall be acid cleaned after the final annealing.

Inspection

17. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the tubes are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection

18. If any test specimen representing a lot fails to meet the requirements of Section 4 and Sections 6 to 8, inclusive, two additional specimens, at the option of the manufacturer, may be taken as before, and submitted to check analysis or subjected to any tests in which the original specimen failed, but each of these specimens shall conform to the requirements specified.

TENTATIVE SPECIFICATIONS
FOR
COPPER-SILICON ALLOY PLATES AND SHEETS[1]

A.S.T.M. Designation: B 96 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934; REVISED, 1936.[2]

By publication of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing the specifications against liability for infringement of Letters Patent nor assume any such liability, and such publication should not be construed as a recommendation of any patented or proprietary application that may be involved.

Scope

1. These specifications cover rolled copper-silicon alloy plates and sheets for pressure vessels.

MANUFACTURE

Manufacture

2. The plates and sheets shall be manufactured by hot rolling or by hot and cold rolling from castings of suitable dimensions.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition

3. The plates and sheets shall conform to the following requirements as to chemical composition:

	TYPE A	TYPE C
Copper, min., per cent	94.80	90.00
Silicon, per cent	2.70 to 3.75	2.30 to 3.75
One or more of the following elements may be present within the limits specified below:		
Manganese, max., per cent	1.50	1.50
Zinc, max., per cent	1.75	4.25
Iron, max., per cent	1.60	1.60
Tin, max., per cent	0.75	1.50
Lead, max., per cent	0.05	0.05
Sum of above elements, min., per cent	99.50	99.50

Chemical Analysis

4. (*a*) Chemical analysis shall be made on each lot of 5000 lb. or fraction thereof.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-5 on Copper and Copper Alloys, Cast and Wrought.

[2] Latest revision accepted by Committee E-10 on Standards, August 26, 1936.

(*b*) The sample for chemical analysis shall be taken by drilling or milling representative plates or sheets in such a way that a sample of the entire thickness of the plates or sheets shall be obtained. Equal quantities from each of the plates and sheets sampled shall be thoroughly mixed. Samples so prepared shall be divided into three equal parts, one for the manufacturer, one for the purchaser, and one for an umpire, if necessary.

PHYSICAL PROPERTIES AND TESTS

Tension Tests

5. The plates and sheets shall conform to the following requirements as to tensile properties. The following values for Rockwell hardness and grain size are given only as information:

	Tensile Strength, lb. per sq. in.	Yield[a] Strength, min., lb. per sq. in.	Elongation in 2 in., min., per cent	Rockwell Hardness[b]		Grain Size,[b] max., mm.
				"F" Scale ($\frac{1}{16}$-in. ball, 60-kg. load)	"B" Scale ($\frac{1}{16}$-in. ball, 100-kg. load)	
Hot rolled	55 000 min.	20 000	50	F 72 min.	.....	....
Hot rolled Cold rolled finish	58 000 to 72 000	29 000	20	.....	B 60 to B 80	....
Annealed	50 000 to 64 000	18 000	40	F 72 to F 92	.....	0.110[c]
Half-hard	71 000 to 81 000	40 000	10	.....	B 79 to B 91	....

[a] Stress corresponding to 0.5 per cent strain.
[b] Hardness and grain size values given only as information.
[c] No minimum grain size requirement is specified, but all annealed material shall be fully recrystallized.

Test Specimens

6. Tension test specimens shall be machined to conform to the dimensions shown in Fig. 6 or 7 of the Standard Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8) of the American Society for Testing Materials.[1] The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

Number of Tests

7. Unless otherwise specified, one tension test shall be made for every lot of 5000 lb. or fraction thereof of each gage or thickness of plates and sheets in the shipment.

PERMISSIBLE VARIATION IN WEIGHT

Permissible Variation in Weight

8. The permissible variation in weights for plates and sheets of all thicknesses and widths shall be ±7½ per cent.

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[1] 1936 Book of A.S.T.M. Standards, Part I, p. 833.

WORKMANSHIP AND FINISH

Workmanship and Finish

9. The plates and sheets shall be free from injurious defects and shall have smooth, clean surfaces, unless otherwise specified. The fracture shall be uniform in color and grain throughout.

MARKING

Marking

10. The name or brand of the manufacturer and the manufacturer's lot identification number shall be legibly stamped or stenciled on each finished plate and sheet in two places not less than 12 in. from the edges. If the plates and sheets are too small to locate the marking as above, the marking may be placed near the center of the plate and sheet. In the case of butt strap, the marking may be placed 12 in. from the end.

INSPECTION AND REJECTION

Inspection

11. The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

Rejection

12. Material which fails to conform to these specifications will be rejected and the manufacturer shall be notified.

TENTATIVE SPECIFICATIONS
FOR
COPPER-SILICON ALLOY RODS, BARS AND SHAPES[1]
A.S.T.M. Designation: B 98 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934; REVISED, 1936.[2]

By publication of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing the specifications against liability for infringement of Letters Patent nor assume any such liability, and such publication should not be construed as a recommendation of any patented or proprietary application that may be involved.

Scope

1. These specifications cover copper-silicon alloy rods, bars and shapes of any cross-section uniform with respect to length.

MANUFACTURE

Manufacture

2. The rods, bars and shapes shall be manufactured by hot and/or cold working, finished by such cold rolling or drawing as may be required, and straightened.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition

3. The material shall conform to the following requirements as to chemical composition:

	TYPE A	TYPE B	TYPE C	TYPE D
Copper, min., per cent.	94.80	97.00	90.00	90.00
Silicon, per cent......	2.70 to 3.75	0.70 to 1.75	2.30 to 3.75	1.00 to 3.75
Lead, per cent.........	.....	.....	.....	0.20 to 0.60[a]
One or more of the following elements may be present within the limits specified below:				
Manganese, max., per cent...............	1.50	0.75	1.50	1.50
Zinc, max., per cent..	1.75	1.25	4.25	4.25
Iron, max., per cent..	1.60	0.80	1.60	1.60
Tin, max., per cent...	0.75	2.25	1.50	2.25
Lead, max., per cent..	0.05	0.05	0.05	.....
Sum of above elements, min., per cent.......	99.50	99.50	99.50	99.50

[a] Either tellurium or selenium may be substituted in Type D alloy in place of lead and in the same amount as that specified for lead.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-5 on Copper and Copper Alloys, Cast and Wrought.

[2] Revision accepted by Committee E-10 on Standards, August 26, 1936.

Chemical Analysis

4. (*a*) Chemical analysis shall be made on each lot of 5000 lb., or fraction thereof.

TABLE I.—TENSION AND BEND TEST REQUIREMENTS.

Temper	Diameter or Distance Between Parallel Faces	Tensile Strength, min., lb. per sq. in.	Yield Point,[a] min., lb. per sq. in.	Elongation in 2 in., min., per cent	Bend Test, Angle of Bend, deg.
TYPES A, C AND D ALLOY RODS, BARS AND SHAPES					
Soft	All forms, all sizes	52 000	......	45	180
Quarter-hard	All forms, all sizes	55 000	24 000	30	120
Half-hard	Rods:				
	Up to ½ in., incl	70 000	38 000	20	120
	Over ½ to 1 in., incl	70 000	38 000	25	120
	Over 1 to 2 in., incl	70 000	38 000	30	120
	Bars and Shapes	[b]	[b]	[b]	[b]
Hard	Rods:				
	Up to ½ in., incl	85 000	50 000	14	90
	Over ½ to 1 in., incl	85 000	50 000	18	90
	Over 1 to 1½ in., incl	85 000	50 000	22	90
	Bars and Shapes	[b]	[b]	[b]	[b]
Extra-hard[c]	Rods:				
	Up to ½ in., incl	100 000	55 000	7	60
	Over ½ to 1 in., incl	100 000	55 000	10	60
	Over 1 to 1¼ in., incl	100 000	55 000	14	60
TYPE B ALLOY RODS, BARS AND SHAPES					
Soft	All forms, all sizes	40 000	......	35	180
Half-hard	Rods:				
	Up to ½ in., incl	55 000	20 000	11	180
	Over ½ to 1 in., incl	55 000	20 000	14	180
	Over 1 to 2 in., incl	55 000	20 000	17	180
	Bars and Shapes	[b]	[b]	[b]	[b]
Hard	Rods:				
	Up to ½ in., incl	65 000	35 000	6	120
	Over ½ to 1 in., incl	65 000	35 000	8	120
	Over 1 to 2 in., incl	65 000	35 000	10	120
	Bars and Shapes	[b]	[b]	[b]	[b]
Extra-hard[c]	Rods:				
	Up to ½ in., incl	75 000	40 000	4	90
	Over ½ to 1 in., incl	75 000	40 000	6	90
	Over 1 to 1½ in., incl	75 000	40 000	8	90

[a] Stress corresponding to 0.5 per cent strain.

[b] Physical requirements of bars and shapes of the half-hard and hard tempers as agreed upon between the manufacturer and the purchaser at time of order.

[c] Bars and shapes are not produced in the extra-hard temper.

(*b*) Drillings or millings for chemical analysis shall be taken from at least four separate pieces, equal quantities being taken from each piece and thoroughly mixed. Samples so prepared shall be divided into three equal parts, each of which shall be placed in a sealed package, one for the manufacturer, one for the purchaser, and one for an umpire, if necessary.

PHYSICAL PROPERTIES AND TESTS

Tension Tests

5. The material shall conform to the minimum requirements as to tensile properties shown in Table I.

Bend Test

6. The bend test specimen shall stand being bent cold through the angle specified in Table I to a radius equal to its diameter or thickness, without fracturing.

Test Specimens

7. (*a*) Tension test specimens shall be as nearly as possible of the same diameter, or distance between parallel faces of the rods, bars or shapes.

(*b*) Bend test specimens may be a piece of full-size rod, shape or bar, or a piece 1 in. in width by ½ in. in thickness. In case of bend test specimens of rectangular section, the edges may be rounded off to a radius equal to one-fourth of the thickness.

Number of Tests

8. (*a*) Rods, bars or shapes shall be grouped into lots of not more than 5000 lb.

(*b*) One tension and one bend test specimen shall be cut from one rod, bar or shape from each lot or fraction thereof.

(*c*) If any part of the fracture of the tension test specimen is more than ¾ in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

PERMISSIBLE VARIATIONS IN DIMENSIONS

Diameter or Thickness

9. (*a*) The diameter of round sections or the distance between parallel faces in the case of other sections, except shapes, shall not vary from that specified by more than the following:

DIAMETER OR THICKNESS, IN.	PERMISSIBLE VARIATIONS, IN.	
	COLD DRAWN	HOT WORKED
Up to and including 0.50	±0.0025	±0.005
Over 0.50 to 1, incl	±0.004	±0.008
Over 1 to 2.5, incl	±0.005	±0.010
Over 2.5	±0.0075	±0.015

(*b*) The permissible variations in dimensions for shapes shall be specified in the contract or purchase order.

Length

10. (*a*) Rods and bars, when ordered to any length, will be received in stock lengths, unless it is specifically stated that the lengths are to be exact.

(*b*) Stock lengths for all rods and bars up to and including 1 in. in diameter or thickness shall be as follows but the weight of lengths less than the length ordered shall not exceed 40 per cent of any one shipment:

ORDERED LENGTH, FT.	PERMISSIBLE VARIATION
12	no length less than 8 ft.
10	no length less than 6 ft.
8	no length less than 6 ft.
6	no length less than 4 ft.

(*c*) For rods and bars over 1 in. up to and including 2 in. in diameter or thickness, the lengths shall be random lengths from 4 to 10 ft.

(*d*) Rods and bars over 2 in. in diameter or thickness shall be ordered in special lengths.

WORKMANSHIP AND FINISH

Workmanship and Finish

11. The rods, bars and shapes shall be free from injurious defects, substantially straight and free from kinks and bends. Unless otherwise specified, they shall have a bright, smooth surface.

INSPECTION AND REJECTION

Inspection

12. The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the rods, bars and shapes are being furnished in accordance with these specifications.

Rejection

13. Rods, bars and shapes which fail to conform to these specifications will be rejected and the manufacturer shall be notified.

TENTATIVE SPECIFICATIONS
FOR
SHEET COPPER-SILICON ALLOY[1]

A.S.T.M. Designation: B 97 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1934; Revised, 1936.[2]

By publication of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing the specifications against liability for infringement of Letters Patent nor assume any such liability, and such publication should not be construed as a recommendation of any patented or proprietary application that may be involved.

Scope

1. These specifications cover sheet copper-silicon alloy, commonly used for drawing, forming, stamping and bending.

MANUFACTURE

Material

2. (*a*) The sheets shall be manufactured by hot working and cold rolling and annealing processes and may be furnished in either the cold rolled or annealed condition, as required.

(*b*) Clean, new scrap resulting from manufacturing operations upon materials complying with these specifications or composed of material of equal purity may be employed.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition

3. The material shall conform to the following requirements as to chemical composition:

	Type A	Type B	Type C
Copper, min., per cent	94.80	97.00	90.00
Silicon, per cent	2.70 to 3.75	0.70 to 1.75	2.30 to 3.75
One or more of the following elements may be present within the limits specified below:			
Manganese, max., per cent	1.50	0.75	1.50
Zinc, max., per cent	1.75	1.25	4.25
Iron, max., per cent	1.60	0.80	1.60
Tin, max., per cent	0.75	2.25	1.50
Lead, max., per cent	0.05	0.05	0.05
Sum of above elements, min., per cent	99.50	99.50	99.50

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-5 on Copper and Copper Alloys, Cast and Wrought.

[2] Latest revision accepted by Committee E-10 on Standards, August 26, 1936.

Chemical Analysis

4. (*a*) Chemical analysis shall be made on each lot of 5000 lb. or fraction thereof.

(*b*) The sample for chemical analysis shall be taken by drilling, milling or clipping representative coils or pieces. Drillings or millings shall be taken on material thicker than 0.040 in. Clippings may be taken with shears from metal thinner than 0.040 in. Equal quantities shall be taken from each piece or coil and thoroughly mixed together. Samples so prepared shall be divided into three equal parts, one for the manufacturer, one for the purchaser, and one for an umpire, if necessary.

PHYSICAL PROPERTIES AND TESTS

Physical Properties

5. The material shall conform to the following requirements as to tensile strength. The following values for Rockwell hardness and grain size are given only as information:

TEMPER	TENSILE STRENGTH, LB. PER SQ. IN.	ROCKWELL HARDNESS, "F" SCALE ($\frac{1}{16}$-IN. BALL, 60-KG. LOAD)	ROCKWELL HARDNESS, "B" SCALE ($\frac{1}{16}$-IN. BALL, 100-KG. LOAD)	GRAIN SIZE, mm.
		Hardness and Grain Size Values for Information Only		
	TYPES A AND C ALLOY SHEET			
0.070 mm. Anneal.	52 000 to 58 000	F 70 to F 82	....	0.050 to 0.110
0.040 mm. Anneal.	55 000 to 64 000	F 76 to F 93	....	0.055 max.[a]
Quarter-hard	62 000 to 72 000	....	B 65 to B 80	....
Half-hard	71 000 to 81 000	....	B 79 to B 91	....
Hard	87 000 to 97 000	....	B 88 to B 96	....
Extra-hard	99 000 to 108 000	....	B 93 to B 98	....
Spring	105 000 to 113 000	....	B 94 to B 99	....
	TYPE B ALLOY SHEET			
0.070 mm. Anneal.	38 000 to 45 000	F 45 to F 55	....	0.050 to 0.120
0.040 mm. Anneal.	40 000 to 50 000	F 50 to F 75	....	0.060 max.[a]
Quarter-hard	42 000 to 52 000	....	B 48 to B 63	....
Half-hard	47 000 to 57 000	....	B 64 to B 73	....
Hard	60 000 to 70 000	....	B 74 to B 82	....
Extra-hard	67 000 to 76 000	....	B 78 to B 85	....
Spring	71 000 to 79 000	....	B 81 to B 86	....

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[a] No minimum grain size requirement is specified but all annealed material shall be fully recrystallized.

(*b*) Special tempers of sheet copper-silicon alloy not covered by these specifications may be agreed upon between the manufacturer and purchaser, in which case they will be specifically defined in the purchase order so that the manufacturer will be able to supply material suitable for its intended use.

Bend Test

6. The bend test specimen shall stand being bent through the angle specified in the table in Section 5 to a radius not less than the thickness and not more than twice the thickness of the sheet, without fracturing.

TABLE I.—PERMISSIBLE VARIATIONS IN THICKNESS, PLUS AND MINUS, IN.

Thickness		Permissible Variations in Thickness, plus and minus, in.		
B. & S. Gage No.	Inch	Up to 8 in. in Width, inclusive	Over 8 to 14 in. in Width, inclusive	Over 14 to 20 in. in Width, inclusive
0000	0.4600	0.0058	0.0062	0.0069
000	0.4096	0.0055	0.0060	0.0066
00	0.3648	0.0054	0.0059	0.0064
0	0.3249	0.0053	0.0056	0.0061
1	0.2893	0.0050	0.0054	0.0060
2	0.2576	0.0049	0.0053	0.0058
3	0.2294	0.0048	0.0051	0.0056
4	0.2043	0.0046	0.0049	0.0054
5	0.1819	0.0044	0.0048	0.0053
6	0.1620	0.0043	0.0046	0.0051
7	0.1443	0.0041	0.0044	0.0049
8	0.1285	0.0040	0.0043	0.0048
9	0.1144	0.0038	0.0041	0.0046
10	0.1019	0.0036	0.0040	0.0044
11	0.0907	0.0035	0.0038	0.0043
12	0.0808	0.0034	0.0036	0.0041
13	0.0720	0.0031	0.0035	0.0040
14	0.0641	0.0030	0.0034	0.0038
15	0.0571	0.0029	0.0033	0.0036
16	0.0508	0.0028	0.0031	0.0035
17	0.0453	0.0026	0.0030	0.0034
18	0.0403	0.0025	0.0029	0.0033
19	0.0359	0.0023	0.0028	0.0031
20	0.0320	0.0021	0.0026	0.0030
21	0.0285	0.0020	0.0025	0.0029
22	0.0253	0.0019	0.0024	0.0028
23	0.0226	0.0018	0.0023	0.0026
24	0.0201	0.0016	0.0021	0.0025
25	0.0179	0.0015	0.0020	0.0024
26	0.0159	0.0014	0.0020	0.0024
27	0.0142	0.0013	0.0019	0.0023
28	0.0126	0.0011	0.0018	0.0021
29	0.0113	0.0010	0.0016	0.0020
30	0.0100	0.0009	0.0015	0.0019
31	0.0089	0.0008	0.0015	0.0019
32	0.0080	0.0008	0.0014	0.0018
33	0.0071	0.0006	0.0013	0.0016
34	0.0063	0.0006	0.0011	0.0016
35	0.0056	0.0005	0.0011	0.0015
36	0.0050	0.0005	0.0010	0.0014
37	0.0045	0.0005	0.0010	0.0014
38	0.0040	0.0004	0.0009	0.0013

Test Specimens

7. Tension test specimens shall be machined to conform to the dimensions shown in Fig. 6 or 7 of the Standard Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8) of the American Society for Testing Materials.[1] The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

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[1] 1936 Book of A.S.T.M. Standards, Part I, p. 833.

Number of Tests

8. Unless otherwise specified, one tension test shall be made for every lot of 5000 lb. or fraction thereof of each gage or thickness of sheet in the shipment.

Permissible Variations in Weight and Dimensions

Width

9. (*a*) The width of slit metal shall not vary more than ±0.010 in.

(*b*) The width of sheared metal shall not vary more than $\pm\frac{1}{16}$ in.

Thickness

10. The standard method of specifying thickness shall be in terms of Brown & Sharpe gage. When thickness is specified in either common or decimal fractions of an inch, the permissible variations in thickness shall be those of a corresponding group of B. & S. gages shown in Table I.

Weight

11. When cold rolled or cold rolled and annealed, sheet copper-silicon alloy over 20 in. in width is specified, a permissible variation of ±7½ per cent of the theoretical weight of the sheet will be allowed.

Length

12. The material may be furnished in coils of flat strips as required. Coils shall consist of not more than three lengths, no one of which shall be less than 10 ft. long. When specific lengths are required they shall be specified in the order. When furnished in flat strips of exact length, a variation of $\frac{1}{16}$ in. over the specified length will be permitted on full length sheets.

Acceptable Short Lengths

13. Lengths of sheet copper-silicon alloy shall be in accordance with the following regular practice:

When ordered in lengths over 10 up to 12 ft..	40 per cent may be 10 ft. and over. 30 per cent may be 8 to 10 ft. 20 per cent may be 6 to 8 ft. 10 per cent may be 4 to 6 ft. Not more than 40 per cent of any one shipment may be less than the length ordered.
When ordered in 10-ft. lengths..............	40 per cent may be 8 ft. and over. 30 per cent may be 6 to 8 ft. 20 per cent may be 4 to 6 ft. 10 per cent may be 2 to 4 ft. Not more than 40 per cent of any one shipment may be less than 10 ft.

When ordered in 8-ft. lengths	30 per cent may be 6 ft. and over. 20 per cent may be 4 to 6 ft. 10 per cent may be 2 to 4 ft. Not more than 30 per cent of any one shipment may be less than 8 ft.
When ordered in 6-ft. lengths	20 per cent may be 4 ft. and over. 10 per cent may be 2 to 4 ft. Not more than 20 per cent of any one shipment may be less than 6 ft.

Finish

14. The sheet copper-silicon alloy shall be free from injurious external and internal defects of a nature which will interfere with the purpose for which it is intended. It shall be well cleaned and free from dirt.

Inspection and Rejection

15. The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

16. Material which fails to conform to these specifications will be rejected and the manufacturer shall be notified.

TENTATIVE SPECIFICATIONS

FOR

COPPER-SILICON ALLOY WIRE FOR GENERAL PURPOSES[1]

A.S.T.M. Designation: B 99 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1935; REVISED, 1935, 1936.[2]

By publication of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing the specifications against liability for infringement of Letters Patent nor assume any such liability, and such publication should not be construed as a recommendation of any patented or proprietary application that may be involved.

Scope

1. These specifications cover round copper-silicon alloy wire for general structural purposes except for electrical transmission cable.

MANUFACTURE

Manufacture

2. The material shall be copper-silicon alloy of such quality and purity that when finished, it shall have the properties and characteristics herein specified.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition

3. (*a*) The material shall conform to the following requirements as to chemical composition:

	TYPE A	TYPE B	TYPE C	TYPE D
Copper, min., per cent	94.80	97.00	90.00	90.00
Silicon, per cent	2.70 to 3.75	0.70 to 1.75	2.30 to 3.75	1.00 to 3.75
Lead, per cent	.....	.....	.....	0.20 to 0.60[a]
One or more of the following elements may be present within the limits specified below:				
Manganese, max., per cent	1.50	0.75	1.50	1.50
Zinc, max., per cent	1.75	1.25	4.25	4.25
Iron, max., per cent	1.60	0.80	1.60	1.60
Tin, max., per cent	0.75	2.25	1.50	2.25
Lead, max., per cent	0.05	0.05	0.05	.....
Sum of above elements, min. per cent	99.50	99.50	99.50	99.50

[a] Either tellurium or selenium may be substituted in Type D alloy in place of lead and in the same amount as that specified for lead.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-5 on Copper and Copper Alloys, Cast and Wrought.

[2] **Latest revision accepted by Committee E-10 on Standards, August 26, 1936.**

Chemical Analysis

4. (*a*) Chemical analysis shall be made on each lot of 5000 lb. or fraction thereof.

(*b*) The sample for chemical analysis shall consist of clean drillings, millings or clippings taken from representative specimens of wire selected for purpose of tests. Equal quantities from each of the specimens sampled shall be thoroughly mixed. Samples so prepared shall be divided into three equal parts, one for the manufacturer, one for the purchaser, and one for an umpire, if necessary.

PHYSICAL PROPERTIES AND TESTS

Physical Properties

5. (*a*) The material shall conform to the requirements as to physical properties shown in Table I.

(*b*) Tests upon a specimen of wire containing a braze or weld shall show at least 95 per cent of the tensile strength of the unbrazed wire. Bend tests shall not be made upon specimens including brazes or welds.

Bend Test

6. All wires of Types A, B, and C alloys shall stand wrapping 360 deg. around a wire of the same diameter without sign of failure. This test shall not be required of material of Type D.

Grain Size Determination

7. In determining grain size, reference should be made to the Standard Rules Governing the Preparation of Micrographs of Metals and Alloys, Including Recommended Practice for Photography as Applied to Metallography (A.S.T.M. Designation: E 2) of the American Society for Testing Materials.[1]

Number of Tests

8. (*a*) Two tension test specimens and one specimen for the bend test or grain size determination, where required, shall be selected from each lot of 10,000 lb. or fraction thereof. Tension and bend tests shall be made on full sections of the wire.

(*b*) If upon testing a specimen from any coil of wire the results are found to be below the values specified in Sections 5 and 6, tests upon two additional specimens shall be made and the average of the three tests shall determine the acceptance or rejection of the coil.

DIMENSIONS AND PERMISSIBLE VARIATIONS

Dimensions and Permissible Variations

9. (*a*) The size shall be expressed as the diameter of the wire in decimal fractions of an inch, using not more than three places of decimals; that is, in mils.

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[1] 1936 Book of A.S.T.M. Standards, Part I, p. 763.

TABLE I.—PHYSICAL PROPERTIES OF COPPER SILICON ALLOY WIRE.

Temper	Physical Properties	Up to ¼ in., incl., in Diameter	Over ¼ in. in Diameter
	Types A, C and D Alloy Wire		
Annealed	Grain size, max., mm	0.040[a]	0.040[a]
	Tensile strength, lb. per sq. in.	55 000 to 70 000	55 000 to 65 000
	Elongation[b] in 2 in., min., per cent	40	47
	Elongation[b] in 10 in., min., per cent	30	[c]
Eighth-hard	Tensile strength, lb. per sq. in.	62 000 to 78 000	62 000 to 78 000
	Elongation[b] in 2 in., min., per cent	20	28
	Elongation[b] in 10 in., min., per cent	7	[c]
Quarter-hard	Tensile strength, lb. per sq. in.	72 000 to 85 000	72 000 to 85 000
	Elongation[b] in 2 in., min., per cent	15	18
	Elongation[b] in 10 in., min., per cent	5	[c]
Half-hard	Tensile strength, min., lb. per sq. in.	90 000	90 000
	Elongation[b] in 2 in., min., per cent	4	10
	Elongation[b] in 10 in., min., per cent	1.5	[c]
Hard	Tensile strength, min., lb. per sq. in.	115 000	115 000
	Elongation[b] in 2 in., min., per cent	2	6
	Elongation[b] in 10 in., min., per cent	0.75	[c]
Spring[d]	Tensile strength, min., lb. per sq. in.	135 000	130 000
	Elongation[b] in 2 in., min., per cent	1.5	4
	Elongation[b] in 10 in., min., per cent	0.5	[c]
	Type B Alloy Wire		
Annealed	Grain size, max., mm	0.040[a]	0.040[a]
	Tensile strength, lb. per sq. in.	43 000 to 50 000	43 000 to 50 000
	Elongation[b] in 2 in., min., per cent	33	40
	Elongation[b] in 10 in., min., per cent	25	[c]
Eighth-hard	Tensile strength, lb. per sq. in.	50 000 to 60 000	50 000 to 60 000
	Elongation[b] in 2 in., min., per cent	12	20
	Elongation[b] in 10 in., min., per cent	4	[c]
Quarter-hard	Tensile strength, lb. per sq. in.	60 000 to 75 000	60 000 to 75 000
	Elongation[b] in 2 in., min., per cent	8	15
	Elongation[b] in 10 in., min., per cent	2.5	[c]
Half-hard	Tensile strength, min., lb. per sq. in.	75 000	75 000
	Elongation[b] in 2 in., min., per cent	4	10
	Elongation[b] in 10 in., min., per cent	1	[c]
Hard	Tensile strength, min. lb. per sq. in.	90 000	90 000
	Elongation[b] in 2 in., min., per cent	3	8
	Elongation[b] in 10 in., min., per cent	0.75	[c]
Spring[d]	Tensile strength, min., lb. per sq. in.	100 000	100 000
	Elongation[b] in 2 in., min., per cent	2	6
	Elongation[b] in 10 in., min., per cent	0.50	[c]

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[a] No minimum grain size requirement is specified but all annealed material shall be fully recrystallized.

[b] Elongation may be determined in either the 2-in. or 10-in. gage length but not in both in any instance.

[c] On wire over ¼ in. in diameter the percentage of elongation shall be taken only in 2 in.

[d] The term "Spring Temper" does not necessarily indicate a reduction of eight B. & S. gage numbers on these alloy wires as in the case of brass.

(*b*) Wire shall be accurate in diameter; permissible variations from the nominal diameter shall be within the following requirements:

WIRE DIAMETER	PERMISSIBLE VARIATION OVER	 UNDER
Under 0.010 in.	0.001 in.	0.001 in.
0.010 in. and over	3 per cent	1 per cent

(*c*) Each coil shall be gaged at three places, one near each end and one approximately at the middle; the coil may be rejected if the measurements at two points being within the accepted limits, the measurement at the third point is not within the accepted limits.

WORKMANSHIP AND FINISH

Workmanship and Finish

10. (*a*) The wire shall be free from all imperfections not consistent with the best commercial practice.

(*b*) Necessary brazes in wire shall be made in accordance with the best commercial practice.

PACKING

Packing

11. (*a*) Package sizes for wire shall be agreed upon by the manufacturer and purchaser in the placing of individual orders.

(*b*) The wire shall be protected against damage in ordinary handling and shipping.

INSPECTION AND REJECTION

Inspection

12. The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

Rejection

13. Material which fails to conform to these specifications will be rejected and the manufacturer shall be notified.

TENTATIVE SPECIFICATIONS

FOR

HARD-DRAWN COPPER ALLOY WIRES FOR ELECTRICAL CONDUCTORS[1]

A.S.T.M. Designation: B 105 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1936.

By publication of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing the specifications against liability for infringement of Letters Patent nor assume any such liability, and such publication should not be construed as a recommendation of any patented or proprietary application that may be involved.

Scope

1. These specifications cover hard-drawn round copper alloy wires for electrical conductors.

Material

2. The material used shall be copper alloy of such nature and composition as to secure by proper treatment the qualities hereinafter specified for the finished wire. The copper used shall be electrolytic or low-resistance lake copper conforming in quality and purity to the requirements of either the Standard Specifications for Electrolytic Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars (A.S.T.M. Designation: B 5)[2] or of the Standard Specifications for Lake Copper Wire Bars, Cakes, Slabs Billets, Ingots, and Ingot Bars (A.S.T.M. Designation: B 4)[3] of the American Society for Testing Materials.

Grades

3. The copper alloy wires may be made in any one of ten distinct grades. The alloys have been designated as Grades Nos. 9 to 85, in accordance with their increasing conductivity, as follows:

Grade No. 9
Grade No. 13
Grade No. 15
Grade No. 20
Grade No. 30
Grade No. 40

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-1 on Copper and Copper Alloy Wires for Electrical Conductors.

[2] 1936 Book of A.S.T.M. Standards, Part I, p. 531.

[3] *Ibid.*, p. 526.

Grade No. 55
Grade No. 65
Grade No. 80
Grade No. 85

Chemical Composition

4. (*a*) The copper alloy wires shall conform to the following requirements as to chemical composition. The values given below embrace limits of composition of the different alloys which may be supplied (see Explanatory Note):

Silicon, max., per cent	3.00
Manganese, max., per cent	0.75
Tin, max., per cent	5.00
Aluminum, max., per cent	3.50
Cadmium, max., per cent	1.50
Iron, max., per cent	0.75
Copper, min., per cent	94.00
Sum of the above elements, min., per cent	99.50

(*b*) The maximum percentage of the various alloying elements to be found in any one of the ten grades is stated in the table in Paragraph (*a*). If the purchaser elects to check the composition of any material supplied to meet the performance requirements of any one of the above ten grades, the composition limits should be made the subject of a definite agreement between the manufacturer and purchaser in the placing of each individual order.

Chemical Analyses

5. Analyses may be made on each lot of 5000 lb. or fraction thereof. Millings or clippings shall be made from at least ten separate coils. Equal quantities shall be taken from each coil and shall be thoroughly mixed together. Samples so prepared shall be divided into three equal parts, each of which shall be placed in a sealed package, one for the manufacturer, one for the purchaser, and one for an umpire, if necessary.

Tensile Strength and Elongation

6. (*a*) The alloy wire of a designated grade shall be so drawn that its tensile strength and elongation shall be at least equal to the values given in Table I. Tension tests shall be made upon fair samples. The elongation of wire larger than 0.204 in. in diameter shall be determined as the permanent increase in length, due to the breaking of the wire in tension, measured between bench marks placed upon the wire originally 10 in. apart. The elongation of wire 0.204 in. or smaller in diameter shall be determined by measurements made between the jaws of the testing machine. The zero length shall be the distance between the jaws when a load equal to 10 per cent of the specified tensile strength shall have been applied, and the final length shall be the distance between the jaws at the time of rupture. The zero length shall be as near 60 in. as possible. The

fracture shall be between the bench marks in the case of wire larger than 0.204 in. in diameter and between the jaws in the case of smaller wire, but not closer than 1 in. to either bench mark or jaw.

(*b*) If upon testing a sample from any coil of wire the results are found to be below the values stated in Table I, tests upon two additional samples shall be made and the average of the three tests shall determine the acceptance or rejection of the coil. For wire whose nominal diameter is between listed sizes, the requirements shall be those of the next larger size given in Table I.

(*c*) Tests upon a section of wire containing a drawn braze shall show at least 95 per cent of the tensile strength of the unbrazed wire. Elongation tests are not to be made upon test sections including brazes.

TABLE I.—MINIMUM REQUIREMENTS FOR TENSILE STRENGTH AND ELONGATION.

Diameter, in.	Area		Tensile Strength, min., lb. per sq. in.								Elongation, min., per cent	
	Circular mils	Square Inch	Grades Nos. 9 and 13	Grades Nos. 15 and 20	Grade No. 30	Grade No. 40	Grade No. 55	Grade No. 65	Grade No. 80	Grade No. 85	in 10 in.	in 60 in.
0.2893	83 690	0.06573....	102 500	109 500	74 000	73 400	76 000	67 500	72 000	68 500	2.17	....
0.2576	66 370	0.05213....	108 800	114 500	80 000	74 900	77 800	68 500	73 500	69 900	1.98	....
0.2294	52 640	0.04134....	112 500	118 500	85 000	76 300	79 300	69 400	75 000	71 200	1.79	....
0.2043	41 740	0.03278....	115 200	121 300	89 000	77 700	80 900	70 200	76 400	72 500	....	1.24
0.1819	33 100	0.02600....	117 200	123 300	92 500	79 000	82 400	71 000	77 500	73 600	....	1.18
0.1620	26 250	0.02062....	119 000	125 000	94 800	80 400	84 000	72 000	78 600	74 700	....	1.14
0.1443	20 820	0.01635....	120 300	126 500	96 500	81 800	85 500	72 900	79 800	75 800	....	1.09
0.1285	16 510	0.01297....	121 600	127 900	97 900	83 200	87 000	74 200	81 000	77 000	....	1.06
0.1144	13 090	0.01028....	122 800	129 200	99 000	84 600	88 500	74 500	82 200	78 100	....	1.02
0.1019	10 380	0.008155...	123 900	130 300	100 100	86 000	90 000	75 100	83 400	79 200	....	1.00
0.09074	8 234	0.006467...	124 800	131 200	101 200	87 100	91 300	75 600	84 600	80 300	....	0.97
0.08081	6 530	0.005129...	125 600	132 000	102 200	88 200	92 600	76 200	85 700	81 400	....	0.95
0.07196	5 178	0.004067...	126 200	132 600	103 000	89 600	93 800	76 800	86 800	82 500	....	0.92
0.06408	4 107	0.003225...	126 700	133 200	103 700	90 400	95 000	77 400	87 800	83 400	....	0.90
0.05707	3 257	0.002558...	127 200	133 600	104 400	91 400	96 000	77 700	88 700	84 200	....	0.89
0.05082	2 583	0.002028...	127 500	134 000	105 200	92 100	97 000	78 100	89 500	85 000	....	0.87
0.04526	2 048	0.001609...	127 800	134 250	105 900	93 100	98 000	78 600	90 300	85 700	....	0.86
0.04030	1 624	0.001276...	128 000	134 500	106 600	94 000	98 600	79 000	91 000	86 400	....	0.85
0.03589	1 288	0.001012...	128 200	134 750	107 300	94 500	99 000	79 300	91 600	87 000	....	0.84
0.03196	1 022	0.0008023..	128 500	135 000	108 000	95 000	99 500	79 600	92 200	87 600	....	0.82

Resistivity

7. Electric resistivity shall be determined upon fair samples by resistance measurements. The resistivity at a temperature of 20 C. (68 F.) shall not be more than the values shown for the designated grade, as follows:

GRADE	MAXIMUM RESISTIVITY, POUNDS PER MILE OHM	MAXIMUM RESISTIVITY, OHMS PER CIRCULAR MIL FOOT
No. 9	9724	115.22
No. 13	6732	79.78
No. 15	5835	69.14
No. 20	4376	51.86
No. 30	2917	34.57
No. 40	2188	25.93
No. 55	1591	18.86
No. 65	1346	15.96
No. 80	1094	12.96
No. 85	1030	12.20

Permissible Variations in Diameter

8. (*a*) The size shall be expressed as the diameter of the wire in decimal fractions of an inch, using not more than three places of decimals; that is, in mils.

(*b*) Wire is expected to be accurate in diameter; permissible variations from nominal diameter shall be as follows:

	OVER	UNDER
For wire 0.057 in. in diameter and larger	3 per cent	1 per cent
For wire less than 0.057 in. in diameter	1 mil	1 mil

(*c*) Each coil may be gaged at three places, one near each end and one approximately at the middle; the coil may be rejected if two points being within the accepted limits, the third point exceeds 4 per cent over, or 2 per cent under the nominal gage in the case of wire 0.057 in. in diameter or larger; or if the third point exceeds $1\frac{1}{2}$ mils over or under the nominal gage in the case of wire less than 0.057 in. in diameter.

Density

9. For the purpose of calculating weights, cross-sections, etc., the density of the various alloys shall be taken as follows, based on a temperature of 20 C. (68 F.):

GRADE	DENSITY
Nos. 9 and 13	8.78 g. per cu. cm., (0.3172 lb. per cu. in.)
No. 15[a]	8.54 g. per cu. cm., (0.3085 lb. per cu. in.) 8.89 g. per cu. cm., (0.3212 lb. per cu. in.)
Nos. 20, 30, 40, 55, 65, 80 and 85	8.89 g. per cu. cm., (0.3212 lb. per cu. in.)

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[a] The lower density value shall be used for alloys of the copper-tin-aluminum type. The higher density value shall be used for the copper-tin alloys.

Finish

10. (*a*) The wire shall be free from all imperfections not consistent with the best commercial practice.

(*b*) Necessary brazes in hard-drawn wire shall be made in accordance with the best commercial practice.

Packing and Shipping

11. (*a*) Package sizes for round wire shall be agreed upon in the placing of individual orders.

(*b*) The wire shall be protected against damage in ordinary handling and shipping.

Inspection

12. All testing and inspection shall be made at the place of manufacture. The manufacturer shall afford the inspector representing the purchaser all reasonable facilities to enable him to satisfy himself that the material conforms to the requirements of these specifications.

EXPLANATORY NOTE

NOTE.—It is the intention of these specifications to permit under each of the ten grades listed in Section 3 any commercial alloy coming within the total range of analysis given in Section 4, provided the product complies with the other requirements of these specifications. For purposes of information only, the types of alloy now commonly used for each of the several grades are listed below. The chemical composition of any of the materials shall be within the total range required in Section 4, but in no case will the alloy contain the allowed maximum of more than one constituent other than copper.

GRADE	ALLOY TYPE
No. 9	Copper, Silicon, Iron Copper, Silicon, Manganese Copper, Silicon, Zinc Copper, Silicon, Tin, Iron Copper, Silicon, Tin, Zinc
No. 13	Copper, Tin, Aluminum Copper, Tin, Silicon Copper, Tin, Silicon, Aluminum
No. 15	Copper, Silicon, Aluminum Copper, Tin Copper, Tin, Aluminum Copper, Tin, Aluminum, Silicon Copper, Tin, Silicon
No. 20	Copper, Tin
No. 30	Copper, Tin
No. 40	Copper, Tin Copper, Tin, Cadmium
No. 55	Copper, Tin, Cadmium
No. 65	Copper, Tin Copper, Tin, Cadmium
No. 80	Copper, Cadmium
No. 85	Copper, Cadmium

TENTATIVE METHOD OF TEST
FOR
FLEXIVITY OF THERMOFLEX (THERMOSTATIC METALS)[1]

A.S.T.M. Designation: B 106 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1936.

Scope

1. (*a*) This method is intended to cover the determination of the flexure-temperature characteristics of thermoflex (thermostatic metals) in the form of flat strips.

(*b*) The characteristics of thermoflex are determined as a whole when tested in the form of a flat strip. No account is taken of the characteristics of the individual components.

(*c*) The procedure involves changing the temperature of a strip of thermoflex and obtaining values indicating the response to temperature changes, or the flexivity, by calculation from the temperatures, dimensions of specimen, and relative movement of gage points on the specimen.

Definitions

2. The following definitions and symbols shall apply in connection with the tests as outlined in this method:

(*a*) *Thermoflex.*—Thermoflex is a composite material usually in the form of sheet or strip, comprising two or more materials of any appropriate nature, metallic or otherwise, which, by virtue of the differing expansivities of its components, tends to change its curvature when subjected to a uniformly distributed change of temperature.

(*b*) *Component.*—A component is one of the plurality of more or less distinct laminae that compose a given thermoflex, and which in cooperation with the other components has a determining effect on the sensitivity to temperature of the thermoflex in so far as tendencies to curvature change are concerned.

(*c*) *Deflection* (*c*).—Deflection as applied to thermoflex is the movement due to temperature change of a chosen point or line thereon, relative to other points or lines, regarded as fixed.

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys.

(*d*) *Deflection, D.*—For the purposes of this test the deflection, D, of a thermoflex strip is the perpendicular distance from a point on the longitudinal center line of the specimen to a line defined by the points of intersection of the longitudinal center line of the specimen with planes passing through the knife edges perpendicularly to the plane of the latter; the first mentioned point being equidistant from the other two.

(*e*) *Flexivity, F.*—The flexivity, F, is the change of curvature per unit temperature change for unit thickness.

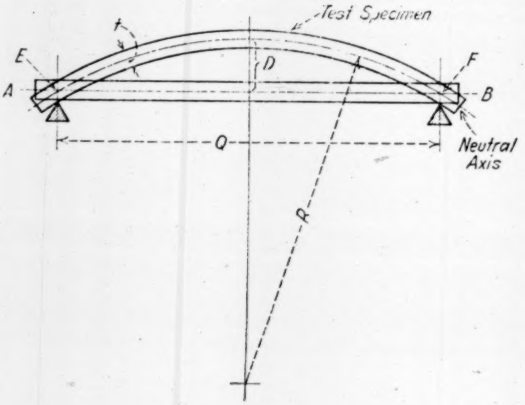

FIG. 1.—Test for Flexivity of Thermoflex.

Referring to Fig. 1,

$$F = \frac{\left(\frac{1}{R_1} - \frac{1}{R_o}\right)t}{T_1 - T_o}$$

$$\text{whence } F = \frac{8t}{(T_1 - T_o)} \left(\frac{D_1}{(Q^2 + 4D^2_1)} - \frac{o}{(Q^2 + 4D^2_o)}\right)$$

where R = Radius of curvature in inches,

R_o = R corresponding to T_o,

R_1 = R corresponding to T_1,

t = thickness in inches,

$T_1 - T_o$ = change in temperature in degrees Fahrenheit,

D = Deflection in inches,

D_o = D corresponding to T_o,

D_1 = D corresponding to T_1, and

Q = Distance between knife edges, in inches.

Test Specimen

3. (*a*) The test specimen shall be in the form of a strip which displays no apparent initial irregularity of curvature.

(*b*) The maximum thickness shall not be greater than the minimum thickness by more than 1 per cent of the latter.

(*c*) The width shall not be less than five times nor more than ten times the thickness. The maximum width shall not be greater than the minimum width by more than 2 per cent of the latter.

(*d*) The length shall be such as to allow a distance between knife edges not less than ten times nor more than fifteen times the mean width, and to extend beyond the knife edges a distance not less than the width. The ratio of the distance between knife edges to the thickness shall be determined to an accuracy of 0.10 per cent.

(*e*) Dimensions of specimens shall be determined by means of screw micrometers or by equivalent methods, to an accuracy of 1 per cent.

NOTE.—For specimens less than 0.050 in. in thickness special precautions are necessary, such as the use of a micrometer reading directly to 0.0001 in., or suitable optical methods may be used.

In the case of very thin specimens (less than 0.010 in. in thickness) the average thickness may be calculated from measurements of length, average width, weight and density. When the density is unknown, it may be determined by weighing a sample of at least 10 g., first in air and then in water. The density in grams per cubic centimeter is equivalent to the weight in air divided by the loss of weight due to submergence in water. The temperature of the water shall be approximately the same as that of the balance room to avoid errors due to convection currents. For the accuracy required, no correction for the temperature of the water or the buoyancy of the air is required. However, care shall be exercised to remove all air bubbles from the sample when weighing it in water, and to avoid the presence of grease or other films on the surface of the water. To this end it is recommended that after a preliminary cleaning to remove obvious dirt the sample be attached to a fine wire, to be used later in suspending it while weighing, and thoroughly rinsed, first in ether, then alcohol, and finally water, before immersing in the water to be used for weighing.

Apparatus

4. The apparatus shall consist of the following:

(*a*) *Specimen Table.*—A specimen table carrying two parallel knife edges to support the specimen. The distance between the knife edges shall be known to within 0.2 per cent.

(*b*) *Micrometer.*—A micrometer, traveling microscope or equivalent device so connected to the specimen table that expansion during heating of the table or connecting parts will not cause appreciable displacement of the measuring device with respect to the knife edges.

(*c*) *Bath.*—A stirred liquid bath or uniformly heated enclosure, in which the specimen table together with adjustable electric heating source is placed, by means of which the specimen can be maintained at the desired temperatures, with a variation in temperature throughout the gage length of the specimen of not to exceed 0.5 per cent of the temperature range used in the test.

(*d*) *Thermocouple or Thermometer.*—Thermocouple wire of known calibration, or calibrated mercury-in-glass thermometers for measuring the temperature of the specimen.

(*e*) *Potentiometer.*—Means for determining the electromotive force of the thermocouples with an accuracy of 1 per cent, and of such sensitivity as to enable the detection of temperature changes of $\frac{1}{4}$ per cent of the temperature range involved in the test.

(*f*) *Transmission Rod.*—Means for measuring the deflection of the strip at a point midway between the knife edges. For this purpose there may be used a fused quartz "transmission rod" terminating in a point or knife edge to engage the specimen at a point midway between the points of contact with the knife edges. This rod shall be suspended from the specimen or otherwise supported with its axis normal to the plane of the knife edges in such a manner that it remains free to move in the direction of its axis. This rod shall bear at its free end an index suitable for microscopic observation, or an electrical contact to permit the changes in the deflection of the specimen to be accurately measured. Alternatively, the deflection of the specimen may be directly observed by optical means whose line of sight is in the plane equidistant from the knife edges and perpendicular to the plane of the latter.

(*g*) The transmission rod and any attached parts shall be of such weight or so counterweighted that they will not cause a deflection greater than 1 per cent of the maximum to be produced by the action of the thermoflex alone. When free, the thermoflex assumes very nearly a circular curvature. Concentrated loading at the center of the specimen will cause the curvature to be other than circular, and may cause significant errors in the evaluation of flexivity. The location of the plane of the knife edges with reference to the scale of the micrometer shall be known to within 0.5 per cent of the maximum deflection.

Preparation of Specimen

5. (*a*) After being roughly cut or sheared from the sample, the specimen shall be finished to size by careful machining or filing. An amount of material extending a distance not less than three times the thickness shall be removed along each edge of the specimen, to eliminate material which may have been damaged in cutting.

(*b*) When the specimen has been finished to size, any necessary reference marks shall be made (by such means as a sharp drill, scribing tool or milling cutter) and their relative locations determined and recorded. Center punches or similar means shall not be used because of the distortion produced.

Procedure

6. (*a*) *Stabilization.*—After all preparatory work on the specimen has been completed, it shall be subjected to a stabilizing heat treatment to relieve internal stresses. This treatment may consist in heating the specimen, while free to bend, for a prescribed time and temperature. The details of the stabilizing procedure will depend upon the characteristics of the thermoflex being tested and shall be as mutually agreed upon by the manufacturer and purchaser.

(*b*) *Test Routine.*—The specimen shall be mounted on the knife edges of the specimen table, the transmission rod put in place and a zero reading taken at room temperature. Slight mechanical pressure shall be applied and then removed at a point near the center of the specimen. If appreciable zero shift is apparent with repeated applications of pressure, the cause shall be determined and removed before proceeding with the test.

(*c*) When satisfactory initial conditions have been established, observations of deflection and temperature shall be made at room temperature, and the results recorded.

(*d*) The temperature of the specimen shall then be adjusted to the next value desired. Thermocouple or thermometer observations at points on or near the center and ends of the specimen shall then be made and recorded.

(*e*) The deflection shall then be observed and recorded.

(*f*) Temperature observations as described in Paragraph (*d*) shall again be made and recorded. If significant discrepancies of temperature or its distribution are found, they shall be corrected and another deflection observation made and recorded.

(*g*) After having secured satisfactory temperature conditions and corresponding deflection data, the next chosen temperature shall be established and the above routine again followed and so on over the range of temperature agreed upon.

(*h*) In all cases, a final set of observations shall be made at or near room temperature to determine whether or not there has been permanent distortion or any mechanical incident that would prevent determination of deflectivity within the desired limits of accuracy. If such is evident, the test shall be repeated under one of the following conditions as agreed upon:

(*1*) The same specimen shall be tested over the same temperature range.

(*2*) The same specimen shall be tested over a different temperature range.

(*3*) Another specimen shall be tested over the same temperature range.

(*4*) Another specimen shall be tested over a different temperature range.

(*i*) *Record.*—Measurements and observations shall be recorded on a data sheet similar to that shown in Table I.

Report

7. The report shall include the following:

(*a*) Class of thermoflex,

(*b*) Identification of specimen,

(*c*) Dimensions of specimen,

TABLE I.—DATA SHEET FOR FLEXIVITY TEST OF THERMOFLEX.

Date.. Class of Thermoflex..................................
Laboratory Name.................................. Sample No...

Dimensions of Specimen: Temperature Range:
Length.................................. .... F. to .... F. to .... F.
Thickness, Average..................
Width.................................. Knife Edge Spacing..............................

Time, sec.	Elapsed Time, sec.	Temperature of Specimens, deg. Fahr.	Deflection, in.	Remarks

First Cycle	Second Cycle
.... F. to .... F. to .... F.	.... F. to .... F. to .... F.

Permanent Set..

(*d*) Spacing of knife edges,

(*e*) Flexivity,

(*f*) A curve showing the relation between flexivity and temperature for each established temperature, and

(*g*) Amount of permanent set at the end of each temperature cycle with reference to original zero reading or room temperature.

TENTATIVE SPECIFICATIONS
FOR
SAND FOR USE IN PLASTER[1]

A.S.T.M. Designation: C 35 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1936.

Quality of Sand.—It is recognized that for certain purposes satisfactory results may be obtained with sands not conforming to these specifications. In such cases the use of sand not conforming to these specifications may be authorized only under special provisions based upon laboratory studies of the possibility of designing a mixture of materials to be used on the job that will yield plaster equivalent in quality to the specified mixture made with sand complying with these specifications in all respects.

Definition

1. Sand[2] for use in plaster shall consist of fine granular material composed of hard, strong, durable, uncoated particles which are free from injurious amounts of saline, alkaline, organic or other deleterious substances.

Grading (Sieve Analysis)

2. (*a*) Sand for use in plaster shall be uniformly graded from fine to coarse within the following limits:

	Percentage Retained	
	Maximum	Minimum
Retained on a No. 4 (4760-micron) sieve	0	..
Retained on a No. 8 (2380-micron) sieve	10	0
Retained on a No. 30 (590-micron) sieve	80	15
Retained on a No. 50 (297-micron) sieve	95	70
Retained on a No. 100 (149-micron) sieve	..	95

(*b*) The sieves shall conform to the requirements of the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials.[3]

Deleterious Substances

3. The amount of deleterious substances, including material finer than a No. 200 sieve, shall not exceed 5 per cent.

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[1] Under the standardization procedure of the Society, these specifications are under the joint jurisdiction of the A.S.T.M. Committee C-7 on Lime and Committee C-11 on Gypsum.

These specifications are in effect a revision and consolidation of, and replace the former Standard Specifications for Sand for Use in Gypsum Plaster (A.S.T.M. Designation: C 35) and the Tentative Specifications for Sand for Use in Lime Plaster (A.S.T.M. Designation: C 66 – 31 T), which specifications were accordingly discontinued in 1936.

[2] The term sand is defined in Standard Definition of the Term Sand (A.S.T.M. Designation: C 58) of the American Society for Testing Materials, 1936 Book of A.S.T.M. Standards, Part II, p. 366.

[3] 1936 Book of A.S.T.M. Standards, Part II, p. 1413.

Organic Impurities

4. The sand when subjected to the colorimetric test for organic impurities shall show a color not darker than the standard color, unless it is shown by adequate tests that the impurities causing the color are not harmful in plaster.

Methods of Testing

5. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Sieve Analysis.*—Standard Method of Test for Sieve Analysis of Aggregates for Concrete (A.S.T.M. Designation: C 41).[1]

(*b*) *Deleterious Substances.*—Tentative Method of Test for Determination of Amount of Material Finer than No. 200 Sieve in Aggregates (A.S.T.M. Designation: C 117 - 35 T).[2]

(*c*) *Organic Impurities.*—Standard Method of Test for Organic Impurities in Sands for Concrete (A.S.T.M. Designation: C 40).[3]

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 353.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 832 (1935); also 1936 Book of A.S.T.M. Tentative Standards, p. 488.

[3] 1936 Book of A.S.T.M. Standards, Part II, p. 350.

TENTATIVE SPECIFICATIONS

FOR

BUILDING BRICK (MADE FROM CLAY OR SHALE)

A.S.T.M. Designation: C 62 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1935; REVISED, 1936.[2]

1. These specifications cover brick made from clay or shale and properly burned, intended for use in brick masonry. Seven grades of brick are covered, as follows:

Grades A, B and C.—These grades are classified according to strength only.

Grades AW-1 and BW-1.—Bricks intended for use where exposed to very severe weathering, such as severe frost action.

Grades AW-2 and BW-2.—Bricks intended for use where exposed to weathering.

Properties

2. (*a*) The bricks shall conform to the physical requirements for the grade specified as follows:

Grade	Compressive Strength (bricks flatwise), lb. per sq. in., **average** gross area		Modulus of Rupture (bricks flatwise), lb. per sq. in., **average** gross area		Water Absorption by 5-hr. boiling, per cent	C/B ratio[a]
	Average of 5 bricks	Individual Minimum	**Average** of 5 bricks	Individual Minimum	Individual Maximum	Individual Maximum
Grade *A*	4500 or more	3500	600 or more	400	......	......
Grade *B*	2500 - 4500	2000	450 or more	300	......	......
Grade *C*	1250 - 2500	1000	300 or more	200	......	......
Grade *AW-1*	4500 or more	3500	......	......	20	0.80
Grade *BW-1*	2500 - 4500	2500	......	......	20	0.80
Grade *AW-2*	4500 or more	3500	......	......	20	0.85
Grade *BW-2*	2500 - 4500	2500	......	......	20	0.85

[a] The ratio C/B is the ratio of absorption by 24-hr. submergence in cold water to that after 5 hr. in boiling water.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee C-3 on Brick.

These Tentative Specifications are in effect a tentative revision of, and are intended to supersede when adopted as standard, the present Standard Specifications for Building Brick (Made from Clay or Shale) (A.S.T.M. Designation: C 62 - 30). 1936 Book of A.S.T.M. Standards, Part, II, p. 119..

[2] Revision accepted by Committee E-10 on Standards, August 26, 1936.

(*b*) If for the 5 bricks tested the average compressive strength is greater than 8000 lb. per sq. in. or the average water absorption is less than 8.0 per cent by weight after 5-hr. submersion in boiling water, or the average water absorption is less than 6.4 per cent by 24-hr. submersion in cold water, the requirement for C/B ratio shall be waived.

(*c*) Unless otherwise specified by the purchaser, bricks of grades *A* and *B* shall be accepted in lieu of grade *C*, grade *A* in lieu of grade *B*, grades *AW-1*, *BW-1* and *AW-2* in lieu of grade *BW-2*, and grade *AW-1* in lieu of grade *AW-2* or *BW-1*.

Test Specimens

3. For purpose of tests, bricks representative of the commercial product shall be selected by a competent person appointed by the purchaser, the place or places of selection to be designated when the purchase order is placed. The manufacturer or purchaser shall furnish specimens for tests without charge. All bricks shall be carefully examined and their condition noted before testing. For the purpose of tests, not less than ten brick shall be required for each investigation. In general, two samples of ten brick each shall be tested for each 100,000 bricks contained in the lot under consideration; but where the total quantity exceeds 500,000, one sample of 10 brick from each 100,000 shall be tested. Additional representative samples may be taken at any time or place at the discretion of the purchaser.

Standard Sizes

4. The standard sizes of brick made from clay or shale shall conform to the following dimensions, within permissible variations of ±$\frac{1}{16}$ in. in depth, ±$\frac{1}{8}$ in. in width, and ±$\frac{1}{4}$ in. in length:

TYPE	DEPTH, IN.	WIDTH, IN.	LENGTH, IN.
Common brick	$2\frac{1}{4}$	$3\frac{3}{4}$	8
Rough-face brick	$2\frac{1}{4}$	$3\frac{3}{4}$	8
Smooth-face brick	$2\frac{1}{4}$	$3\frac{7}{8}$	8

Workmanship and Finish

5. When any particular surface appearance or uniformity is desired, it shall be as mutually agreed upon by the manufacturer and purchaser.

Visual Inspection

6. All brick shall conform to the following requirements for general properties under visual inspection:

(*a*) They shall be free from cracks, warpage, stones, pebbles, or particles of lime that would affect their serviceability or strength.

(*b*) Bricks of grade *A* or grade *B* when struck together shall give a ringing sound.

Acceptance

7. At the option of the purchaser, acceptance of grades *A*, *B*, and *C*

may be based on the visual inspection requirements specified in Section 6 and the results of one of the strength tests (compressive strength or modulus of rupture) specified in Section 2. While the compressive strength is considered as generally giving the better basis for classification purposes, the flexure test gives important information on the strength and proper manufacturing details.

Methods of Testing

8. The bricks shall be tested in accordance with the Tentative Methods of Testing Brick (Modulus of Rupture, Compressive Strength, Absorption) (A.S.T.M. Designation: C 67 – 36 T) of the American Society for Testing Materials.[1]

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[1] See p. 780.

TENTATIVE SPECIFICATIONS

FOR

GLAZED BUILDING UNITS[1]

A.S.T.M. Designation: C 126 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1936.[2]

Scope

1. These specifications cover brick, tile, and other masonry building units of clay or shale with a finish consisting of a vitreous glaze, excluding natural salt glazed ware.

Sizes

2. (*a*) The units shall be of the sizes and shapes specified (see Explanatory Note 1), no dimension differing by more than 2 per cent from that specified.

(*b*) The units may be either solid or cored, but the area of the cells shall not exceed 40 per cent of the gross area of a section perpendicular to the axis of the cells. The area of the cells in units intended for use where subjected to impact shall not exceed 25 per cent of the gross sectional area.

Workmanship

3. (*a*) All units shall be straight with sharp edges and corners, unless otherwise specified. Faces intended to be plane shall have no distortions greater than 1 per cent of the larger dimension of the face.

(*b*) All surfaces that will be exposed when the units are in place shall be finished with a glaze of uniform quality. The glaze shall be free from chips, crazes, blisters, crawling and other imperfections.

Finish

4. The texture and color of the finish shall be as specified (see Explanatory Note 2).

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee C-3 on Brick.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 26, 1936.

Imperviousness of Finish

5. No trace of the stain shall remain on the finish after the staining test, except that, if a finish with a matt texture is specified, a slight discoloration in depressions will not be cause for rejection.

Opacity of Finish

6. When an opaque glaze is specified no penetration of the stain shall be visible through the finish within 5 min. after the staining solution has been applied in the opacity test.

Acid Resistance of Finish

7. Neither the texture nor the color of the finish shall be altered by the exposure in the acid resistance test.[1]

Resistance to Crazing

8. The finish shall not craze, spall, peel, or crack during the exposure in the autoclave test.

Absorption of Body

9. When the units are intended for use where exposed to frost action, the absorption of the body of the unit by 24-hr. submersion in cold water shall not exceed 14 per cent, and *in addition* the units shall conform to at least *one* of the following requirements for absorption:

(*a*) The absorption by 24-hr. submersion in cold water shall not exceed 7 per cent.

(*b*) The ratio of the absorption by 24-hr. submersion in water to the absorption by 5-hr. submersion in boiling water shall not exceed 0.80.

Inspection

10. Facilities shall be provided the purchaser for sampling and inspection at either the plant or the site of the construction, as specified by the purchaser. At least 5 days from the time of sampling shall be allowed for the completion of the tests.

Rejection

11. At the option of the purchaser, a lot of units may be rejected if it fails to meet any of the requirements of these specifications.

SAMPLING AND METHODS OF TESTING

Sampling

12. (*a*) Specimens of whole building units shall be selected by the purchaser or his representative at the place or places designated in the purchase order.

(*b*) Five specimens shall be tested for a lot of 10,000 units or fraction thereof; for larger lots 5 additional specimens shall be tested for each 30,000 units or fraction thereof.

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[1] Intended as a measure of resistance of colored finishes to fading.

(*c*) Other samples may be taken at any time or place at the discretion of the purchaser.

(*d*) The manufacturer or seller shall furnish for testing, without charge, a minimum of 10 units and additional specimens up to 0.1 per cent of each size and finish in the lot.

Imperviousness of Finish Test

13. Liquid ink or methylene blue shall be applied liberally to the finish, and allowed to remain for 5 min. The surface shall then be washed with a wet cloth and running water, and examined for staining of the finish.

Opacity Test of Finish

14. Liquid ink or methylene blue shall be applied to the body of dry specimens of glazed building units at an edge of a finished surface. After 5 min. the finish shall be examined for opacity.

Acid Resistance Test of Finish

15. A portion of the glazed surface of one or more of the specimens of each texture and color shall be submerged in a 10 per cent solution of hydrochloric acid at a temperature of 60 to 80 F. (15 to 27 C.) for 3 hr. The finish shall then be rinsed, dried, and examined for changes of texture and color.

Resistance to Crazing Test (Autoclave Test)

16. Dry specimens, previously tested for imperviousness of finish (Section 13), shall be placed above the water in an autoclave. Units which have been tested also for opacity (Section 14) and acid resistance of finish (Section 15) may be used. The pressure within the autoclave shall be increased gradually by admitting saturated steam or by heating the water, the air being allowed to escape until substantially all of the air has been replaced by steam. The pressure shall be increased to between 20 and 50 lb. per sq. in. in 30 min., to between 60 and 100 lb. per sq. in. in 60 min., and to 150 lb. per sq. in. in from 80 to 120 min. after the beginning of the steaming. The pressure shall be held at 150 ± 5 lb. per sq. in. for 1 hr. The pressure shall then be released in a period of from 10 to 30 min. and the specimens then allowed to cool gradually to room temperature. A record of either the temperature or the pressure within the autoclave shall be maintained, including values of either temperature or pressure at intervals not to exceed 10 min. during the test. Ink of a color differing from that of the stain used in the test for imperviousness of finish shall then be applied to the finish and allowed to stand for 5 min. The surface shall then be washed with a wet cloth and running water, and examined for crazing of the glaze.

EXPLANATORY NOTES

NOTE 1.—The following sizes and shapes are standard in the industry:

HEIGHT, IN.	LENGTH, IN.	THICKNESS, IN.
$2\frac{1}{4}$	8	$1\frac{3}{4}$, $1\frac{7}{8}$, or $3\frac{7}{8}$
$3\frac{7}{8}$	8	$1\frac{3}{4}$, $1\frac{7}{8}$, or $3\frac{7}{8}$
5	8	$1\frac{3}{4}$, $1\frac{7}{8}$, or $3\frac{7}{8}$
5	10	$1\frac{3}{4}$, $1\frac{7}{8}$, or $3\frac{7}{8}$
5	12	$1\frac{3}{4}$, $1\frac{7}{8}$, or $3\frac{7}{8}$
6	12	$1\frac{3}{4}$, $1\frac{7}{8}$, or $3\frac{7}{8}$
$7\frac{7}{8}$	$7\frac{7}{8}$	$1\frac{3}{4}$, $1\frac{7}{8}$, or $3\frac{7}{8}$
$7\frac{7}{8}$	16	$1\frac{3}{4}$, $1\frac{7}{8}$, or $3\frac{7}{8}$
$10\frac{1}{4}$	12	$1\frac{3}{4}$, $1\frac{7}{8}$, or $3\frac{7}{8}$
12	12	$1\frac{3}{4}$, $1\frac{7}{8}$, or $3\frac{7}{8}$

NOTE 2.—As an aid to the designer, the textures and colors listed below are standard in the industry. All colors and textures, however, are not available in all areas; additional colors and textures are available in some markets. It is suggested, therefore, that the designer inquire into the colors and textures available in the locality where the product is to be used.

CHART OF TEXTURES AND COLORS OF GLAZED BUILDING UNITS STANDARD IN THE INDUSTRY

Textures		Colors		
Ceramic Glazed	Coated Glaze	Glazed	Ceramic Glazes	
			Light Shades	*Trim Shades*
Lustrous Gloss Satin Matt Porcelain	Gloss	Gray Cream Light buff Medium buff Dark buff Orange Maroon Blends of Grays and Creams Creams and Light Buffs Light and Medium Buffs Medium and Dark Buffs Full Range	White Cream Ivory Buff Tan Gray Various Light Speckles Stipples or Ripples of the above light colors Mottles of two or more of the above light colors Mottles of light and trim colors, predominatingly of light colors	Black Browns Blues Greens Reds Yellow Gold Stipples, Ripples, or Mottles of the above dark colors Mottles of trim and light colors, predominatingly dark

TENTATIVE METHODS OF TESTING BRICK[1]

(MODULUS OF RUPTURE, COMPRESSIVE STRENGTH, ABSORPTION)

A.S.T.M. Designation: C 67 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1935; REVISED, 1936.[2]

Scope

1. These methods cover the following tests for brick:

Modulus of rupture (flexure test)
Compressive strength
Absorption

Definition of Terms

2. The Standard Definitions of Terms Relating to Methods of Testing (A.S.T.M. Designation: E 6) of the American Society for Testing Materials,[3] shall be considered as applying to the terms used in these methods.

MODULUS OF RUPTURE (FLEXURE TEST)

Apparatus

3. The testing machine, or other calibrated testing device, used for the flexure test of brick shall conform to the requirements of the Standard Methods of Verification of Testing Machines (A.S.T.M. Designation: E 4) of the American Society for Testing Materials.[4]

Test Specimen

4. The test specimen shall consist of a whole brick. The specimen shall be dried to constant weight at a temperature of 100 to 105 C. (212 to 221 F.). It shall be cooled to room temperature before testing.

Number of Specimens

5. Flexure tests shall be made on at least five test specimens.

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee C-3 on Brick.

These tentative methods are in effect a tentative revision of, and are intended to supersede when adopted as standard, the present Standard Methods of Testing Brick (Compression, Flexure, Absorption) (A.S.T.M. Designation: C 67 – 31), 1936 Book of A.S.T.M. Standards, Part II, p. 140.

[2] Revision accepted by Committee E-10 on Standards, August 26, 1936.

[3] 1936 Book of A.S.T.M. Standards, Parts I and II, pp. 861 and 1429, respectively.

[4] *Ibid.*, pp. 849 and 1417, respectively.

Flexure Test

6. (*a*) The test specimen shall be supported flatwise on a span of 7 in. and loaded at mid-span. The load shall be applied to the upper surface of the specimen through a steel bearing plate ¼ in. in thickness and 1½ in. in width and of a length at least equal to the width of the specimen. The direction of the load shall be perpendicular to the loaded surface of the specimen.

(*b*) The supports for the test specimen shall be free to rotate in the longitudinal and transverse direction of the test specimen and shall be adjusted so that they will exert no force in these directions.

(*c*) The speed of the moving head of the testing machine (or other calibrated testing device) during the application of the load shall not exceed 0.05 in. per min.

Modulus of Rupture

7. (*a*) The modulus of rupture of each specimen shall be calculated by the use of the following formula:

$$\text{Modulus of rupture, lb. per sq. in.} = \frac{3Wl}{2bd^2}$$

where W = the maximum load indicated by the testing machine, in pounds;
l = the distance between the supports in inches (7 in.);
b = the average over-all breadth, face to face, of the specimen, in inches, and
d = the average over-all depth, face to face, of the specimen, in inches.

(*b*) The average of the modulus of rupture determinations of all the specimens tested shall be reported as the modulus of rupture of the lot of brick.

COMPRESSIVE STRENGTH TEST

Apparatus

8. (*a*) The testing machine used for the compressive strength test of brick shall conform to the requirements of the Standard Methods of Verification of Testing Machines (A.S.T.M. Designation: E 4) of the American Society for Testing Materials.[1]

(*b*) The testing machine shall be equipped with a lubricated spherical bearing block.

Test Specimen

9. The test specimen shall consist of a half-brick, with approximately plane and parallel ends. The specimen may be obtained from a whole brick by any method that will produce, without shattering, a half-brick.

NOTE.—This permits the use of suitable half-bricks available after the transverse test has been made.

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[1] 1936 Book of A.S.T.M. Standards, Parts I and II, pp. 849 and 1417, respectively.

Number of Specimens

10. Compressive strength tests shall be made on at least five test specimens, each from a different brick.

Preparation of Specimen

11. (*a*) If the flatwise faces of the test specimen are recessed or paneled, the depressions shall be filled with a neat Portland cement paste, which shall then be allowed to age at least 24 hr. before the specimen is capped.

(*b*) The two opposite flatwise faces of each specimen shall be coated with shellac which shall be allowed to dry thoroughly.

(*c*) One of the dry shellacked faces of the specimen shall be bedded in a thin coat of a neat paste of calcined gypsum (plaster of Paris) which has been spread on an oiled non-absorbent plate such as glass or a machined metal plate. This procedure shall be repeated with the other dry shellacked face. Care shall be taken that the opposite bearing surfaces so formed will be approximately parallel. The capping shall be allowed to age at least 2 hr. before the compression test is made.

Compression Test

12. (*a*) The specimen shall be tested flatwise (that is, the load shall be applied in the direction of the thickness of the brick).

(*b*) The spherical bearing block shall be placed between a capped face of the specimen and the platen of the testing machine. If a vertical testing machine is used, the spherical bearing shall be placed on top of the specimen. The center of the spherical surface of the block shall be in the plane of the bearing surface of the specimen and in an axis of the specimen. The spherical bearing block shall be adjusted by rotating it under a small initial load.

(*c*) When the load on the specimen exceeds approximately one-half of the maximum load, the rate of loading shall be such that the load will be read accurately. Preferably, the rate of loading should not exceed 2000 lb. per sq. in. per min., but this requirement may be considered as being met if the speed of the moving head of the testing machine during the application of the load is not more than 0.05 in. per min.

Compressive Strength

13. (*a*) The compressive strength of each specimen shall be calculated by the use of the following formula:

$$\text{Compressive strength, lb. per sq. in.} = \frac{W}{A}$$

where W = the maximum load indicated by the testing machine, in pounds, and

A = the average of the gross areas of the upper and lower bearing surfaces of the specimen, in square inches.

(*b*) The average compressive strength of all the specimens tested shall be reported as the compressive strength of the lot of brick.

ABSORPTION TEST

24-Hour Submersion Test

Test Specimen

14. A test specimen shall consist of a half-brick conforming to the requirements of Section 9.

Number of Specimens

15. Absorption tests shall be made on at least five test specimens.

Absorption Test

16. (*a*) The test specimen shall be dried to constant weight in a ventilated oven at a temperature of 110 to 115 C. (230 to 239 F.).

NOTE.—It can be assumed that heating for 72 hr. at these temperatures will assure constant weight except for deaired bricks or bricks whose absorption is less than 8.0 per cent by 5-hr. submersion in boiling water as determined under Section 20 (*c*).

(*b*) When cool, the specimen shall be weighed on scales or balances sensitive to within 0.1 per cent.

(*c*) The dry specimen shall be immediately submerged without preliminary partial immersion in clear water (soft, distilled or rain water) at a temperature of 15.5 to 30 C. (60 to 86 F.) for 24 hr. The specimen shall then be removed, the surface water wiped off with a damp cloth, and the specimen weighed. Weighing of any one specimen shall be completed within 5 min. after removing the specimen from the bath.

Absorption

17. (*a*) The absorption of each specimen shall be calculated by the use of the following formula:

$$\text{Absorption, per cent} = \frac{100\,(b-a)}{a}$$

where a = the dry weight of the specimen, and
b = the saturated weight of the specimen.

(*b*) The average absorption of all the specimens tested shall be reported as the absorption of the lot of brick.

5-Hour Boiling Test

Test Specimen

18. A test specimen shall consist of a half-brick conforming to the requirements of Section 9.

Number of Specimens

19. Absorption tests shall be made on at least five test specimens.

Absorption Test

20. (*a*) The specimen which has been saturated 24 hr. in the cold-water submersion bath shall be returned to the bath and subjected to a 5-hr. boiling test as described in Paragraph (*c*).

(*b*) When cool, the specimen shall be weighed on a scale or balance sensitive to within 0.1 per cent.

(*c*) The dry specimen shall be submerged in clear water (soft, distilled or rain water) at a temperature of 15.5 to 30 C. (60 to 86 F.) in such a manner that water can circulate freely on all sides of the specimen. The water shall be heated to boiling within 1 hr., boiled continuously for 5 hr. and then allowed to cool to a temperature of 15.5 to 30 C. (60 to 86 F.) by natural loss of heat for not less than 16 nor more than 18 hr. The specimen shall then be removed, the surface water wiped off with a damp cloth, and the specimen weighed. Weighing of any one specimen shall be completed within 5 min. after removing the specimen from the bath.

NOTE.—If the tank is equipped with a drain so that water at a temperature of 15.5 to 30 C. (60 to 86 F.) can be passed through the tank continuously and at such a rate that a complete change of water takes place in not more than 2 min., weighings can be made at the end of 1 hr.

Absorption

21. (*a*) The absorption of each specimen shall be calculated by the use of the following formula:

$$\text{Absorption, per cent} = \frac{100\,(b-a)}{a}$$

where: a = the dry weight of the specimen, and
b = the saturated weight of the specimen.

(*b*) The average absorption of all the specimens tested shall be reported as the absorption of the lot of brick.

Absorption Ratio

22. The C/B ratio of each specimen shall be calculated by the use of the following formula:

$$\text{Absorption ratio } (C/B) = \frac{b-a}{B-a}$$

where a = the dry weight of the specimen,
b = the saturated weight of the specimen after 24-hr. submersion in cold water, and
B = the saturated weight of the specimen after 5-hr. submersion in boiling water.

TENTATIVE METHOD OF PANEL TEST
FOR
RESISTANCE TO THERMAL AND STRUCTURAL SPALLING OF SUPER DUTY FIRECLAY BRICK[1]

A.S.T.M. Designation: C 122 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1936.

Scope

1. This method is intended to show the resistance of super duty fireclay brick to the separate and combined effects of structural and thermal spalling. This method makes use of the general requirements and procedure prescribed in the Standard Method of Panel Test for Resistance of Refractory Brick to Thermal and Structural Spalling (A.S.T.M. Designation: C 38) of the American Society for Testing Materials,[2] and supplements that method by giving the detailed requirements of the procedure to be followed in testing these brick.

Apparatus and Test Specimen

2. The apparatus and test specimen shall be in general as described in the Standard Method of Panel Test for Resistance of Refractory Brick to Thermal and Structural Spalling (A.S.T.M. Designation: C 38) of the American Society for Testing Materials.[2]

Procedure

3. The procedure shall be in general as outlined in the Standard Method C 38,[2] supplemented by the procedure for preheating and spalling as prescribed in the following Sections 4 and 5.

Preheating

4. Details of the procedure for preheating shall be as follows:

(*a*) The test brick shall be laid up with kaolin having a Pyrometric Cone Equivalent not below Standard Pyrometric Cone No. 34.

(*b*) The test panels shall be backed up with insulation, the thermal conductivity of which shall be such that the heat loss will be approximately

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee C-8 on Refractories.

[2] 1936 Book of A.S.T.M. Standards, Part II, p. 212.

900 B.t.u. per square foot per hour. The mean temperature of the insulation shall be approximately 700 C.

(*c*) The temperature of the panel faces shall be maintained so as to average 1650 C. by means of a gas-fired furnace for a period of 24 hr.

Spalling

5. Details of the procedure for spalling shall be as follows:

(*a*) The panel insulation shall be removed.

(*b*) The gas-fired furnace shall be operated so as to obtain a temperature of 1400 C. before the panels are cooled by means of the blast.

(*c*) The period for heating shall be 10 min. and for cooling 10 min., making a 20-min. cycle.

(*d*) The cooling shall be accomplished by means of an air-water mist blast, which shall be delivered through a vertical manifold with an opening measuring $3\frac{1}{2}$ by 24 in. as shown in the Standard Method C 38[1]. Air shall be delivered through each cooling unit at the rate of 1400 cu. ft. per minute. The water used in the four spray units shall be filtered and measured by means of a meter. The spray nozzles shall be regulated so as to deliver water at the rate of $2\frac{1}{2}$ gal. during the first 8 min. of the cycle. No water shall be used during the last 2 min. The cooling units shall be operated with a reciprocating motion so as to pass back and forth across the surface of the entire panel, including the dummy guard brick, 125 times in 10 min.

(*e*) The spalling treatment shall consist of 12 cycles, after which the furnace shall be shut off and the panels given two additional cooling cycles without the water mist.

(*f*) After carefully dismantling the panel, the kaolin shall be scraped off with a trowel, removing such pieces of the brick that separate easily. No attempt shall be made to separate pieces that might be removed by prying or tapping.

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 212.

TENTATIVE DEFINITIONS OF TERMS RELATING TO REFRACTORIES[1]

A.S.T.M. Designation: C 71 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1936.

Insulating Brick.—A product manufactured in standard brick shapes used primarily for heat insulation purposes.

Insulating Fire Brick.—A product with low-heat conductivity suitable for use as a lining for furnaces.

Calcining.—In the case of refractories manufacture, the heating of raw materials to redness or a higher temperature.

Burning (*Firing*).—In the case of refractories manufacture, the heat treatment of a refractory mix at a temperature high enough to develop a bond by partial vitrification.

Hard-Burned Refractory Ware.—Ware which has been subjected to a maximum intensity of heat treatment practicable.

Light-Burned Refractory Ware.—Ware which has been subjected to a minimum intensity of heat treatment practicable.

Medium-Burned Refractory Ware.—Ware which has been subjected to heat treatment of intermediate intensity.

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[1] Under the standardization procedure of the Society, these definitions are under the jurisdiction of the A.S.T.M. Committee C-8 on Refractories.

These definitions, when adopted as standard, will be added to the Standard Definitions of Terms Relating to Refractories (A.S.T.M. Designation: C 71 - 36), 1936 Book of A.S.T.M. Standards, Part II, p. 255.

TENTATIVE SPECIFICATIONS
FOR
CONCRETE AGGREGATES[1]

A.S.T.M. Designation: C 33 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1921; Revised, 1923, 1926, 1928, 1930, 1931, 1936.

QUALITY OF AGGREGATES

It is recognized that for certain purposes satisfactory results may be obtained with materials not conforming to these specifications. In such cases the use of fine and coarse aggregates not conforming to these specifications may be authorized only under special provisions based upon laboratory studies of the possibility of designing a mixture of materials to be used on the job that will yield concrete equivalent in quality to the specified mixture made with material complying with these specifications in all respects.

FINE AGGREGATE

General Characteristics. 1. Fine aggregate shall consist of sand or other approved inert materials with similar characteristics, or a combination thereof, having hard, strong, durable particles and shall conform to the requirements of these specifications.

Deleterious Substances. 2. (*a*) The amount of deleterious substances shall not exceed the following maximum requirements:

	Maximum Permissible Percentage by Weight
Removed by decantation	3
Coal	1
Clay lumps	1
Other local deleterious substances (such as shale, alkali, mica, coated grains, soft and flaky particles)	....
Total coal, clay lumps, shale, soft fragments and other local deleterious substances	5

Note.—It is recognized that under certain conditions percentages of deleterious substances less than those shown in the table should be specified as a maximum.

(*b*) All fine aggregate shall be free from injurious amounts of organic impurities. Aggregates subjected to the colorimetric test for organic impurities and producing a color darker than the standard shall be rejected unless they pass the mortar strength test as specified in Section 4.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee C-9 on Concrete and Concrete Aggregates.

Grading.

3. (*a*) Fine aggregate shall be well graded from coarse to fine and when tested by means of laboratory sieves[1] shall conform to the following requirements:

	PER CENT
Passing a ⅜-in. sieve	100
Passing a No. 4 sieve	(95) to (100)
Passing a No. 16 sieve	(45) to (80)
Passing a No. 50 sieve	(5) to (30)
Passing a No. 100 sieve	(0) to (8)

NOTE.—Figures in parentheses are suggested as limiting percentages but they may be altered within these limits to suit local conditions.

Uniformity.

(*b*) The above gradation for fine aggregate represents the extreme limits which shall determine the suitability for use of fine aggregate from all sources of supply. The gradation of fine aggregate from any one source shall be reasonably uniform and not subject to the extreme percentages of gradation specified above. For the purpose of determining the degree of uniformity of a fine aggregate, a fineness modulus determination shall be made upon representative samples of fine aggregate, from such sources as are proposed for use. Fine aggregate from any one source having a variation in fineness modulus greater than 0.20 either way from the fineness modulus of the representative sample submitted by the contractor shall either be rejected or may be accepted subject to such adjustment in proportions as may be necessary by reason of changes in grading of fine aggregate. Fine aggregate from different sources of supply shall not be mixed or stored in the same pile nor used alternately in the same class of construction or mix, without permission from the engineer.

(*c*) In case the concrete resulting from a mixture of aggregates approaching the extreme limits for gradation is not of a workable character, or when finished does not exhibit a proper surface, due to an excess of particles approximately ⅛ to ½ in. in size, either a fine aggregate having a sufficiently greater percentage of fine material, or a coarse aggregate having a sufficiently smaller percentage of fine material shall be used.

Mortar Strength.

4. Fine aggregate shall be of such quality that when made into a mortar and subjected to the mortar strength test (Section 10 (*e*)) it shall develop a compressive strength at 7 and 28 days of not less than .... per cent[2] of that developed by a mortar prepared in the

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[1] For detail requirements for these sieves, see the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials, 1936 Book of A.S.T.M. Standards, Part II, p. 1413.

[2] A percentage should be inserted by the engineer to suit local conditions.

same manner with the same cement and graded Ottawa sand having a fineness modulus of 2.40 ± 0.10.

NOTE.—The graded Ottawa sand mentioned above may be obtained with a mixture of approximately equal parts by weight of standard Ottawa sand and run-of-mine Ottawa sand.

COARSE AGGREGATE

General Characteristics.

5. Coarse aggregate shall consist of crushed stone, gravel, blast-furnace slag, or other approved inert materials of similar characteristics, or combinations thereof, having hard, strong, durable pieces, free from adherent coatings and conforming to the requirements of these specifications.

Deleterious Substances.

6. The amount of deleterious substances shall not exceed the following maximum requirements:

	MAXIMUM PERMISSIBLE PERCENTAGE BY WEIGHT
Removed by decantation	1½
Shale (removed by flotation test)	1
Coal	1
Clay lumps	0.5
Soft fragments	5
Other local deleterious substances (such as alkali, friable, thin, elongated, or laminated pieces)	----
Total shale, coal, clay lumps and soft fragments	5

NOTE.—It is recognized that under certain conditions percentages of deleterious substances less than those shown in the table should be specified as a maximum.

Grading.

7. (*a*) Coarse aggregate shall be well graded, between the limits specified, and shall conform to the following requirements:

CRUSHED STONE, GRAVEL AND BLAST-FURNACE SLAG

Designated Size	Percentages Passing Laboratory Sieves Having Square Openings						
	2 in.	1½ in.	1 in.	¾ in.	½ in.	⅜ in.	No. 4
2 in. to No. 4	95 to 100	....	35 to 70	....	10 to 30	....	0 to 5
1½ in. to No. 4	....	95 to 100	....	35 to 70	....	10 to 30	0 to 5
1 in. to No. 4	....	....	90 to 100	....	25 to 60	....	0 to 10
¾ in. to No. 4	....	....	....	90 to 100	....	20 to 55	0 to 10
½ in. to No. 4	....	....	....	....	90 to 100	....	0 to 15
2 in. to 1 in	90 to 100	35 to 70	0 to 15	....	....	....	......
1½ in. to ¾ in	....	90 to 100	20 to 55	0 to 15	....	....	......

(*b*) Designation of a given coarse aggregate as aggregate of a certain maximum size shall be understood to mean that more than 5 per cent must be retained on the next smaller of the sieves appearing in the above table.

(*c*) In case the concrete resulting from a mixture of aggregates approaching the extreme limits for gradation is not of a workable character, or when finished does not exhibit a proper surface, due to an excess of particles approximately $\frac{1}{8}$ to $\frac{1}{2}$ in. in size, either a fine aggregate having a sufficiently greater percentage of fine material or a coarse aggregate having a sufficiently smaller percentage of fine material shall be used.

Weight of Slag.

8. Blast-furnace slag that meets the grading requirements of these specifications shall conform to the following minimum weight requirements:

General concrete	65 lb. per cu. ft.
Concrete subject to abrasion	70 lb. per cu. ft.

Durability.

9. Coarse aggregate shall pass a sodium sulfate accelerated soundness test, except that aggregates failing in the accelerated soundness test may be used if they pass a satisfactory freezing and thawing test.

Note.—Many engineers believe that an abrasion test for coarse aggregate to be used in concrete subject to abrasion is important, but no test limits are specified, due to the status of knowledge concerning suitable specification limits for this test. The committee believes that the abrasion tests when applied to blast-furnace slag do not meet the requirements for a desirable test. This recommendation is made after consideration of the results of a study to determine the value of the abrasion test as to the concrete making properties of slag.

METHODS OF SAMPLING AND TESTING

Methods of Testing.

10. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials, except as specified in Paragraphs (*j*) and (*k*):

(*a*) *Sampling.*—Standard Methods of Sampling Stone, Slag, Gravel, Sand and Stone Block for Use as Highway Materials, Including Some Material Survey Methods (A.S.T.M. Designation: D 75).[1]

(*b*) *Sieve Analysis.*—Standard Method of Test for Sieve Analysis of Aggregates for Concrete (A.S.T.M. Designation: C 41).[2]

(*c*) *Decantation Test.*—Standard Method of Decantation Test for Sand and Other Fine Aggregates (A.S.T.M. Designation: D 136),[3] or the Standard Method of Test for Quantity of Clay and Silt in Gravel for Highway Construction (A.S.T.M. Designation: D 72).[4]

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 1092.

[2] *Ibid.*, p. 353.

[3] *Ibid.*, p. 1051.

[4] *Ibid.*, p. 1050.

(*d*) *Organic Impurities.*—Standard Method of Test for Organic Impurities in Sands for Concrete (A.S.T.M. Designation: C 40).[1]

(*e*) *Mortar Strength.*—Standard Method of Test for Structural Strength of Fine Aggregate Using Constant Water-Cement-Ratio Mortar (A.S.T.M. Designation: C 87).[2]

(*f*) *Compressive Strength.*—Standard Methods of Making Compression Tests of Concrete (A.S.T.M. Designation: C 39).[3]

(*g*) *Soundness.*—Tentative Method of Test for Soundness of Coarse Aggregates by Use of Sodium Sulfate or Magnesium Sulfate (A.S.T.M. Designation: C 89 - 35 T).[4]

(*h*) *Freezing and Thawing.*—Method of freezing-and-thawing tests of drain tile as described in the Standard Specifications for Drain Tile (A.S.T.M. Designation: C 4).[5]

(*i*) *Coal and Lignite.*—Tentative Method of Test for Coal and Lignite in Sand (A.S.T.M. Designation: C 123 - 36 T).[6]

(*j*) *Shale.*—Method of Test for Percentage of Shale in Aggregate,[7] Tentative Method T-10 of The American Association of State Highway Officials.

(*k*) *Soft Fragments.*—Method of Test for Quantity of Soft Pebbles in Gravel,[7] Tentative Method T-8 of The American Association of State Highway Officials.

(*l*) *Moisture.*—Standard Method of Test for Surface Moisture in Fine Aggregate (A.S.T.M. Designation: C 70).[8]

(*m*) *Weight of Slag.*—Standard Method of Test for Unit Weight of Aggregate for Concrete (A.S.T.M. Designation: C 29).[9]

(*n*) *Abrasion.*—If abrasion tests are made the following methods of test are recommended:

> (1) *Abrasion of Gravel.*—Tentative Method of Test for Abrasion of Gravel (A.S.T.M. Designation: D 289 - 28 T).[10]
>
> (2) *Abrasion of Rock.*—Standard Method of Test for Abrasion of Rock (A.S.T.M. Designation: D 2),[11] except that for specific gravities lower than 2.2 a 4000-g. sample shall be used.

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 350.

[2] *Ibid.*, p. 355.

[3] *Ibid.*, p. 342.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 837 (1935); also 1936 Book of A.S.T.M. Tentative Standards, p. 502.

[5] 1936 Book of A.S.T.M. Standards, Part II, p. 257.

[6] See p. 794.

[7] See "Tentative Standard Specifications for Highway Materials and Methods of Sampling and Testing," The Am. Assn. State Highway Officials, pp. 98, 97 (1935), also 1928 Report of Committee C-9 on Concrete and Concrete Aggregates, see *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, pp. 362, 363 (1928).

[8] 1936 Book of A.S.T.M. Standards, Part II, p. 357.

[9] *Ibid.*, p. 364.

[10] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 940 (1928); also 1936 Book of A.S.T.M. Tentative Standards, p. 738.

[11] 1936 Book of A.S.T.M. Standards, Part II, p. 1040.

(*o*) *Fineness Modulus.*—The fineness modulus is the sum of percentages in the sieve analysis divided by 100 when the sieve analysis is expressed as cumulative percentages coarser than each of sieves Nos. 100, 50, 30, 16, 8, 4, etc. The sieves shall conform to the requirements of the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials.[1] The sieve analysis shall be made in accordance with the Standard Method of Test for Sieve Analysis of Aggregates for Concrete (A.S.T.M. Designation: C 41) of the American Society for Testing Materials.[2]

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 1413.

[2] *Ibid.*, p. 353.

TENTATIVE METHOD OF TEST
FOR
COAL AND LIGNITE IN SAND[1]

A.S.T.M. Designation: C 123 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1936.

Scope

1. This method of test is intended for the approximate determination of coal and lignite in the routine laboratory examination of sands. This method separates, along with the coal and lignite, other particles of low specific gravity, such as small pieces of wood, vegetable matter, etc.

Apparatus

2. The apparatus shall consist of the following:

(*a*) *Balance.*—The balance shall have a capacity of at least 200 g. and shall be sensitive to 0.01 g. A less sensitive balance may be used in weighing the wet sample.

(*b*) *Container.*—A container suitable for drying the sand sample.

(*c*) *Beakers.*—Two 400-ml. tall-form, lipped beakers.

(*d*) *Wire Gauze or Sieve.*—Wire gauze or a small sieve having about 60 openings per inch. A piece of wire gauze would probably be more suitable than a sieve.

(*e*) *Hot Plate or Oven.*

Procedure

3. Coal and lignite in sand shall be determined as follows:

Weigh a quantity in excess of 200 g. of sand (sampled wet) and dry to constant weight at a temperature of approximately 105 C. Weigh accurately a 200-g. sample of the dry sand to the nearest 0.01 g. Pour this sample slowly into about 250 ml. of carbon tetrachloride (sp. gr. about 1.58) contained in one of the 400-ml. beakers. Place the wire gauze or sieve over the other beaker and pour the carbon tetrachloride through the gauze or sieve, taking care that only the floating particles are poured off with the liquid and that none of the sand is decanted onto the gauze or sieve. The carbon tetrachloride collected in the second beaker shall then be returned to the beaker containing the sand; and after further agitation of the sample by stirring, the decanting process just described shall be repeated until the sample is free of floating particles. The decanted particles contained on the gauze or sieve will dry very quickly, but may be placed in an oven at 105 C. for a few minutes if desired. The decanted particles shall then be brushed from the gauze or sieve onto the balance pan and the weight accurately determined to the nearest 0.01 g.

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee C-9 on Concrete and Concrete Aggregates.

Calculation

4. The approximate percentage of coal and lignite shall be calculated from the following formula:

$$\text{Percentage of coal and lignite} = \frac{\text{Wt. of decanted particles}}{\text{Wt. of dry sample (200 g.)}} \times 100$$

TENTATIVE LABORATORY METHOD

OF

MAKING FLEXURE TESTS OF CONCRETE, USING A SIMPLE BEAM WITH THIRD POINT LOADING[1]

A.S.T.M. Designation: C 78 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1930; REVISED, 1936.

Scope

1. These methods cover the making of flexure tests of concrete in the laboratory where accurate control of quantities of materials and test conditions is possible. They are intended to apply to hand-mixed concrete with slight modification from those used in making compression test specimens, described in the Standard Methods of Making Compression Tests of Concrete (A.S.T.M. Designation: C 39) of the American Society for Testing Materials.[2]

Preparation of Materials

2. Materials shall be brought to room temperature (18 to 24 C., 65 to 76 F.), before beginning the tests. Cement shall be stored in a dry place, preferably in covered metal cans. The cement shall be thoroughly mixed in advance, in order that the sample may be uniform throughout the tests. It shall be sieved through a No. 16 (1190-micron) sieve and all lumps rejected. Aggregates shall be in a room-dry condition when used in concrete tests. In general, coarse aggregates should be separated on the No. 4 (4760-micron), $\frac{3}{8}$, $\frac{3}{4}$, 1, $1\frac{1}{2}$, 2, $2\frac{1}{2}$ and 3-in. sieves and recombined to the average original sieve analysis for each batch. Fine aggregate should be separated into different sizes also, in cases where unusual gradings are being studied.

Sampling for Preliminary Tests

3. Representative samples of all concrete materials shall be secured for preliminary tests prior to the proportioning and mixing of the concrete. Test samples of cement may be made up of a small quantity from each sack used in the concrete tests. Test samples of aggregates may be taken from larger lots by quartering.

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee C-9 on Concrete and Concrete Aggregates.

[2] 1936 Book of A.S.T.M. Standards, Part II, p. 342.

Cement Tests

4. Cement shall be tested in accordance with the Standard Methods of Sampling and Testing Portland Cement (A.S.T.M. Designation: C 77) of the American Society for Testing Materials.[1]

Fine Aggregate Tests

5. Fine aggregates (passing through a No. 4 (4760-micron) sieve shall be subjected, when specified, to the following tests of the American Society for Testing Materials:

(*a*) *Sieve Analysis.*—Standard Method of Test for Sieve Analysis of Aggregates for Concrete (A.S.T.M. Designation: C 41).[2]

(*b*) *Organic Impurities.*—Standard Method of Test for Organic Impurities in Sands for Concrete (A.S.T.M. Designation: C 40).[3]

(*c*) *Determination of Material Passing No. 200 Sieve.*—Tentative Method of Test for Determination of Amount of Material Finer than No. 200 Sieve in Aggregates (A.S.T.M. Designation: C 117 – 35 T).[4]

(*d*) *Unit Weight.*—Standard Method of Test for Unit Weight of Aggregate for Concrete (A.S.T.M. Designation: C 29).[5]

(*e*) *Specific Gravity.*—Tentative Method of Test for Specific Gravity and Absorption of Fine Aggregate (A.S.T.M. Designation: C 128 – 36 T).[6]

(*f*) *Tensile Strength.*—Strength test of 1:3 mortar by weight at 7 and 28 days in comparison with standard sand mortar in accordance with the Standard Methods of Sampling and Testing Portland Cement (A.S.T.M. Designation: C 77).[1]

Coarse Aggregate Tests

6. Coarse aggregates (retained on a No. 4 (4760-micron) sieve) shall be subjected when required to the following tests of the American Society for Testing Materials:

(*a*) *Sieve Analysis.*—Standard Method of Test for Sieve Analysis of Aggregates for Concrete (A.S.T.M. Designation: C 41).[2]

(*b*) *Determination of Material Passing No. 200 Sieve.*—Tentative Method of Test for Determination of Amount of Material Finer than No. 200 Sieve in Aggregates (A.S.T.M. Designation: C 117 – 35 T).[4]

(*c*) *Unit Weight.*—Standard Method of Test for Unit Weight of Aggregate for Concrete (A.S.T.M. Designation: C 29).[5]

(*d*) *Specific Gravity.*—Tentative Method of Test for Specific Gravity and Absorption of Coarse Aggregate (A.S.T.M. Designation: C 127 – 36 T).[7]

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 9.

[2] *Ibid.*, p. 353.

[3] *Ibid.*, p. 350.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 832 (1935); also 1936 Book of A.S.T.M. Tentative Standards, p. 488.

[5] 1936 Book of A.S.T.M. Standards, Part II, p. 364.

[6] See p. 808.

[7] See p. 805.

Unit Weight of Mixed Aggregates

7. The unit weight of mixed fine and coarse aggregates as used in the concrete tests shall be determined in accordance with the method specified in Section 5 (*d*).

Proportions

8. The quantities of each size of aggregate to be used in each batch shall be determined on the basis of the sieve analyses of the fine and coarse aggregates and the unit weight of the mixed aggregates. The exact quantities of cement and of each size of aggregate for each batch shall be determined by weight. The quantity of water for each batch shall be accurately measured. The quantities of materials may be expressed as follows:

(*a*) 1 volume of cement to .... volumes of total aggregate mixed as used, or

(*b*) 1 volume of cement to .... volumes of fine aggregate, and .... volumes of coarse aggregate, or

(*c*) 1 part by weight of cement, ... parts by weight of fine aggregate, and .... parts by weight of coarse aggregate.

Size and Shape of Test Specimens

9. (*a*) The following minimum cross-sections shall be used for the flexure test specimens:

SIZE OF COARSE AGGREGATE, IN.	WIDTH, IN.	DEPTH, IN.
$1\frac{1}{2}$	6	6
2 and $2\frac{1}{2}$	8	6

(*b*) The span of the test specimen shall be 18 in.

Mixing Concrete

10. Concrete shall be mixed by hand in batches of such size as to leave a small quantity of concrete after molding a single test specimen or a series of identical test specimens to be tested at different ages. The batch shall preferably be mixed with a shovel in a water-tight, shallow, galvanized pan, as follows:

(*a*) The cement and fine aggregate shall be mixed dry until the mixture is homogeneous in color.

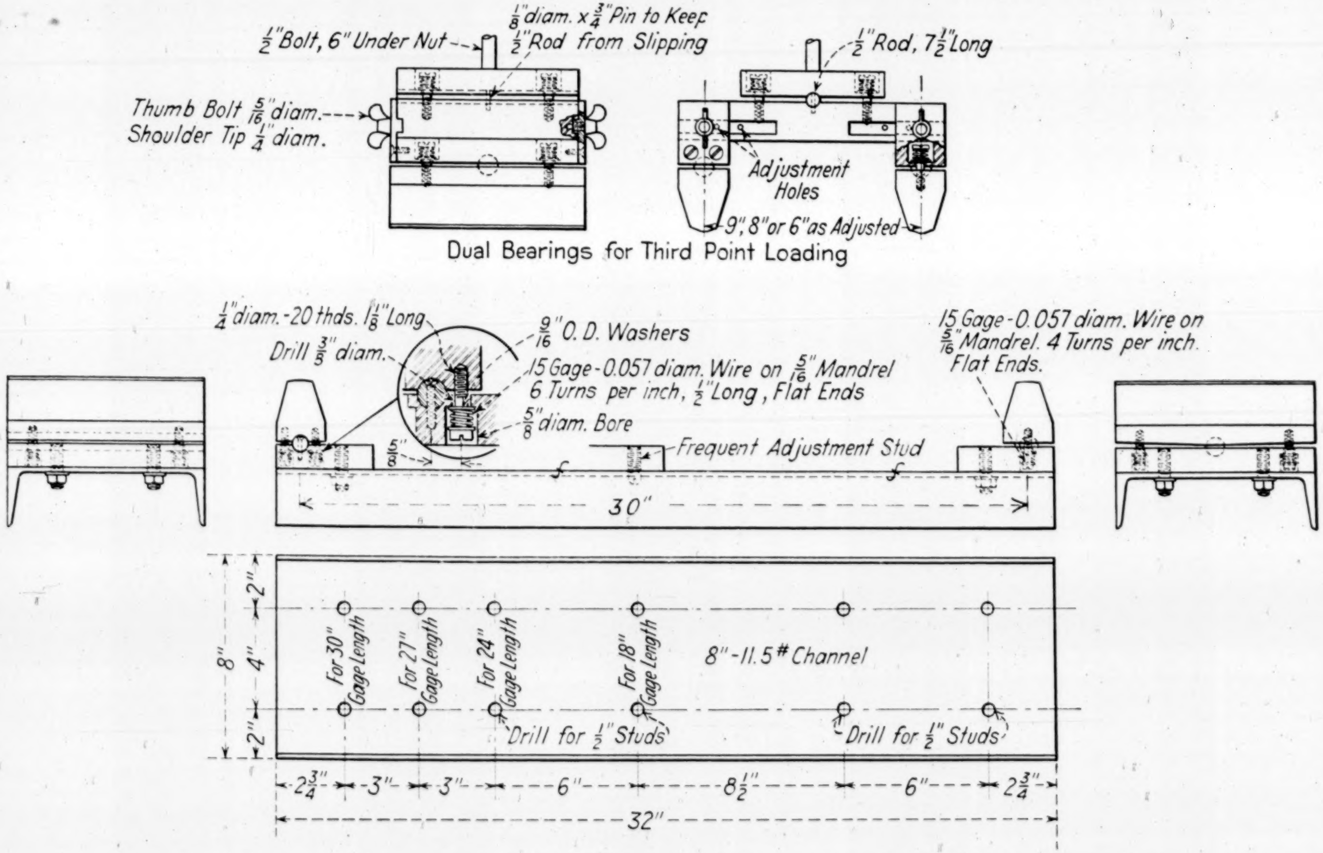
(*b*) The coarse aggregate shall be added and mixed dry.

(*c*) Sufficient water shall be added to produce concrete of the desired consistency.

(*d*) The mass shall be mixed thoroughly for at least 3 min. or until the resulting concrete is homogeneous in appearance.

Consistency

11. The consistency of each batch of concrete shall be measured by the slump test made in accordance with the Tentative Method of Test for



Dual Bearings for Third Point Loading

$\frac{1}{8}$" diam. x $\frac{3}{4}$" Pin to Keep $\frac{1}{2}$" Rod from Slipping
$\frac{1}{2}$" Bolt, 6" Under Nut
Thumb Bolt $\frac{5}{16}$" diam. Shoulder Tip $\frac{1}{4}$" diam.
$\frac{1}{2}$" Rod, $7\frac{1}{2}$" Long
Adjustment Holes
9", 8" or 6" as Adjusted
$\frac{1}{4}$" diam.-20 thds. $1\frac{1}{8}$" Long
Drill $\frac{3}{8}$" diam.
$\frac{9}{16}$" O. D. Washers
15 Gage-0.057 diam. Wire on $\frac{5}{16}$" Mandrel 6 Turns per inch, $\frac{1}{2}$" Long, Flat Ends
$\frac{5}{8}$" diam. Bore
$\frac{5}{8}$"
Frequent Adjustment Stud
15 Gage-0.057 diam. Wire on $\frac{5}{16}$" Mandrel. 4 Turns per inch. Flat Ends.
f
f
30"
For 30" Gage Length
For 27" Gage Length
For 24" Gage Length
For 18" Gage Length
8"-11.5# Channel
Drill for $\frac{1}{2}$" Studs
Drill for $\frac{1}{2}$" Studs
2"
4"
2"
8"
$2\frac{3}{4}$"
3"
3"
6"
$8\frac{1}{2}$"
6"
$2\frac{3}{4}$"
32"

FIG. 1.—Details of Design of Apparatus for Flexure Test of Concrete by Third Point Loading Method.

Consistency of Portland-Cement Concrete (A.S.T.M. Designation: D 138 – 32 T) of the American Society for Testing Materials.[1]

Forms

12. (*a*) The forms and base shall be rigid, water-tight and nonabsorptive. The forms shall be well braced and also tightly joined together to prevent slipping.

(*b*) The inside faces of the form shall be oiled with a heavy paraffin base oil or a thin coating of paraffin shall be applied.

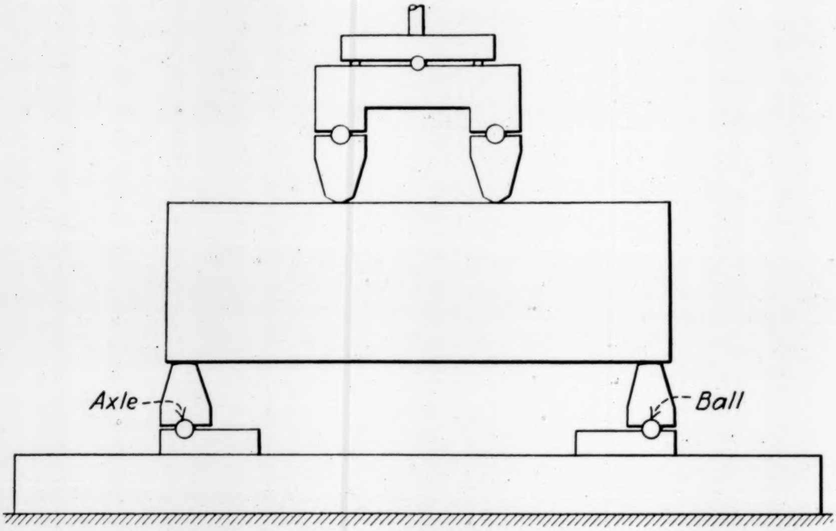


FIG. 2.—Diagrammatic View of Apparatus for Flexure Test of Concrete by Third Point Loading Method.

Molding Test Specimens

13. In molding test specimens the concrete shall be placed in two equal layers not exceeding 3 in. in depth. Each layer shall be rodded 50 times for each square foot of area. The top layer shall be such that the beam form is slightly heaped up with concrete. After the rodding is completed for each layer, the specimen shall be spaded along the sides and ends with a mason's trowel or other suitable spading tool. When the rodding and spading operation is completed, the top shall be struck off with a straight edge and finished with a cork float. The test specimen shall be made as quickly as possible and immediately covered over with a double layer of damp burlap.

Curing Test Specimens

14. The test specimens shall be removed from the forms, except the bottom section, 20 to 24 hr. after molding, marked, weighed and then stored in damp sand, under damp cloths, or in a moist chamber until the

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 775 (1932); also 1936 Book of A.S.T.M. Tentative Standards, p. 741.

date of test. The temperature of the curing room shall be maintained within a range of 60 to 75 F. (16 to 24 C.).

Number of Specimens

15. The number of specimens to be tested shall be three or more made on different days.

Measurement of Specimens

16. Measurements shall be made to the nearest 0.01 in. of the average width and average depth of the specimen at the section of failure.

Type of Transverse Testing Machine

17. The third point loading method shall be used in making flexure tests of concrete employing bearing blocks which will insure that forces applied to the beam will be vertical only and applied without eccentricity. A design of an apparatus which accomplishes this purpose is shown in Fig. 1.

Application of Load

18. The specimen with the molded top up, shall be carefully centered on the transverse blocks and the load-applying blocks brought in contact with the upper surface of the test specimen at the third points between the supports. A diagrammatic view of the set-up is shown in Fig. 2. The load may be applied rapidly up to approximately 50 per cent of the breaking load, after which it should be applied at a rate such that the extreme fibers are stressed 150 lb. per sq. in. or less per minute.

Record of Test

19. The report shall include the following:

(*a*) Results of the following tests of aggregates:
  Organic impurities,
  The weight per cubic foot,
  Sieve analysis,
  Material finer than a No. 200 sieve,
  Tensile strength test of fine aggregate,
  The specific gravity,
  Nature of the aggregate:
    (*1*) Composition (kind of minerals of which it is composed),
    (*2*) Gravel, crushed stone, slag,
    (*3*) Source of supply, and
    (*4*) Any additional information.

(*b*) Complete data on the acceptance tests of the portland cement,

(*c*) The proportions of each batch including the quantities of water, cement, fine and coarse aggregates used together with the weight per cubic foot and the yield,

(*d*) The consistency or slump of each batch,
(*e*) The weight and size of the test specimen including the weight when made, the weight when tested and the measurements at time of test,
(*f*) The curing conditions,
(*g*) The kind of machine used in testing, condition of end supports and the span length,
(*h*) The breaking load, type of failure and its exact location,
(*i*) The rate of application of the load, and
(*j*) The age of the test specimen at time of test.

TENTATIVE METHOD OF TEST

FOR

FLOW OF PORTLAND-CEMENT CONCRETE BY USE OF THE FLOW TABLE[1]

A.S.T.M. Designation: C 124 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1936.

Scope

1. This method is intended for determining the flow of concrete.

Apparatus

2. (*a*) *Mold.*—The mold shall be made of a smooth metal casting in the form of the frustum of a cone with a base 10 in. in diameter, upper surface $6\frac{3}{4}$ in. in diameter and altitude 5 in.; the base and the top shall be open and at right angles to the axis of the cone. The mold shall be provided with handles. (See Fig. 1.)

(*b*) *Flow Table.*—The flow table shall conform to the design shown in Fig. 2 and shall be mounted on and bolted to a concrete base having a height of 15 to 20 in. and weighing not less than 300 lb.

Sample

3. The sample to be tested shall be obtained from the concrete immediately after the completion of the mixing. When testing concrete from a central mixing plant or transit mixer, the sample shall be obtained and tested immediately after the concrete is discharged from the truck.

Procedure

4. Immediately preceding the test, the table top shall be wetted and cleaned of all gritty material and the excess water removed with a rubber squeegee. The mold, centered on the table, shall be firmly held in place and filled in two layers, each approximately one-half the volume of the mold. Each layer shall be rodded with 25 strokes of a round, non-metallic rod $\frac{5}{8}$ in. in diameter and 24 in. in length, having a bullet-pointed end. The strokes shall be distributed in a uniform manner over the cross-section of the mold and shall penetrate into the underlying layer. The bottom layer shall be rodded throughout its depth. After the top layer has been

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee C-9 on Concrete and Concrete Aggregates.

rodded, the surface of the concrete shall be struck off with a trowel so that the mold is exactly filled. The excess concrete which has overflowed the mold shall be removed and the area of the table outside of the mold again cleaned. The mold shall be immediately removed from the concrete by a steady, upward pull. The table shall then be raised and dropped ½ in., 15 times in about 10 sec. The diameter of the spread concrete shall be the average of six symmetrically distributed caliper measurements read to the nearest ¼ in.

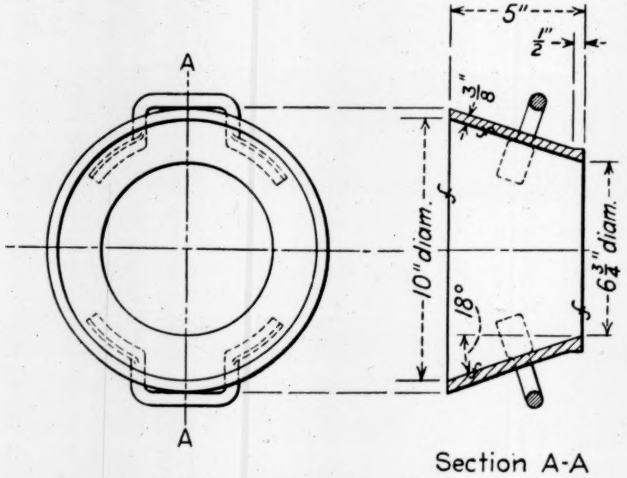
5"
½"
3/8"
A
A
10" diam.
6¾" diam.
18°
f
f
Section A-A

FIG. 1.—Mold for Flow Test.

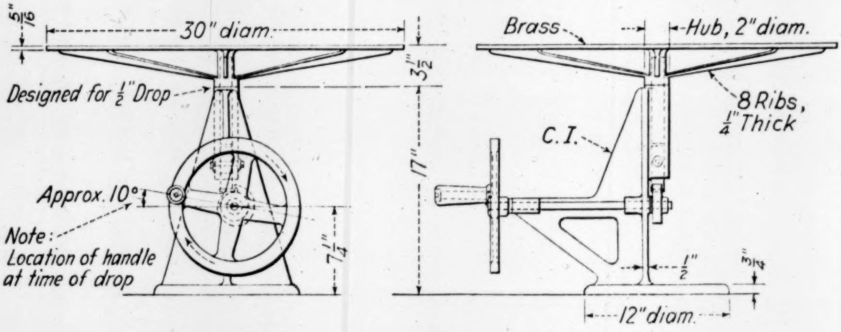
5/16"
30" diam.
3½"
Designed for ½" Drop
17"
Approx. 10°
Note: Location of handle at time of drop
7¼"
Brass
Hub, 2" diam.
8 Ribs, ¼" Thick
C.I.
½"
3/4"
12" diam.

FIG. 2.—Flow Table Assembly.

Flow

5. The flow of the concrete shall be recorded as the percentage of increase in diameter of the spread concrete over the base diameter of the molded concrete, calculated from the following formula:

$$\text{Flow, per cent} = \frac{(\text{Spread Diameter} - 10 \text{ in.})}{10} \times 100$$

TENTATIVE METHOD OF TEST
FOR
SPECIFIC GRAVITY AND ABSORPTION OF COARSE AGGREGATE[1]

A.S.T.M. Designation: C 127 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1936.[2]

Scope

1. This method of test is intended for use in making determinations of bulk and apparent specific gravity, and absorption after 24 hr. in water at room temperature, of coarse aggregate. The bulk specific gravity is the value generally desired for calculations in connection with portland-cement concrete. The method determines directly the bulk specific gravity as defined in Section 4 of the Standard Definitions of Terms Relating to Specific Gravity (A.S.T.M. Designation: E 12) of the American Society for Testing Materials,[3] or the bulk specific gravity on the basis of weight of saturated surface-dry aggregate, or the apparent specific gravity as defined in Section 3 of the Standard Definitions E 12.[3]

Apparatus

2. The apparatus shall consist of the following:

(*a*) *Balance.*—A balance having a capacity of 5 kg. or more and sensitive to 0.5 g. or less.

(*b*) *Wire Basket.*—A wire basket of No. 4 mesh wire, approximately 8 in. in diameter and 8 in. in height.

(*c*) Suitable container for immersing wire basket in water and suitable apparatus for suspending wire basket from center of scale pan of balance.

Sample

3. Approximately 5 kg. of the aggregate shall be selected from the sample to be tested by the method of quartering, rejecting all material

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[1] Under the standardization procedure of the Society, this method is under the joint jurisdiction of the A.S.T.M. Committee C-9 on Concrete and Concrete Aggregates and Committee D-4 on Road and Paving Materials.

This method is in effect a revision and consolidation of, and replaces the former Standard Method of Test for Apparent Specific Gravity of Coarse Aggregates (D 30 - 18) and the former Tentative Method of Test for Apparent Specific Gravity of Coarse Aggregates in a Saturated Condition (C 86 - 31 T), which methods were accordingly discontinued in 1936. The procedure for determining absorption in this method is in effect a tentative revision of, and will supersede when adopted as standard, the present Standard Method of Test for Absorption by Aggregates for Concrete (Laboratory Determinations) (C 95 - 36), 1936 Book of A.S.T.M. Standards, Part II, p. 330.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 26, 1936.

[3] 1936 Book of A.S.T.M. Standards, Part II, p. 1436.

passing a $\frac{3}{8}$-in. sieve. In the case of homogeneous aggregate, all material may be retained on a 1-in. sieve.

Procedure

4. (*a*) The sample shall be immersed in water at 15 to 25 C., thoroughly agitated to remove dust or other coatings from the surface of the particles and then allowed to absorb water for 24 hr. It shall then be removed from the water and rolled in a large absorbent cloth until all visible films of water are removed, although the surfaces of the particles still appear to be damp. The larger fragments may be individually wiped. Care should be taken to avoid evaporation during the operation of surface drying. The weight of the sample in the saturated surface-dry condition shall then be obtained. This and all subsequent weights shall be determined to the nearest 0.5 g.

(*b*) After weighing, the saturated surface-dry sample shall be placed immediately in the wire basket and its weight in water determined.

(*c*) The sample shall then be dried to constant weight at a temperature of 100 to 110 C., cooled to room temperature, and weighed.

Bulk Specific Gravity

5. The bulk specific gravity as defined in Section 4 of the Standard Definitions of Terms Relating to Specific Gravity (A.S.T.M. Designation: E 12) of the American Society for Testing Materials,[1] shall be calculated from the following formula:

$$\text{Bulk specific gravity} = \frac{A}{B - C}$$

where A = weight in grams of oven-dry sample in air,
B = weight in grams of saturated surface-dry sample in air, and
C = weight in grams of saturated sample in water.

Bulk Specific Gravity (Saturated Surface-Dry Basis)

6. The bulk specific gravity on the basis of weight of saturated surface-dry aggregate shall be calculated from the following formula:

$$\begin{array}{c}\text{Bulk specific gravity}\\ \text{(saturated surface-dry basis)}\end{array} = \frac{B}{B - C}$$

Apparent Specific Gravity

7. The apparent specific gravity as defined in Section 3 of the Standard Definitions of Terms Relating to Specific Gravity (A.S.T.M. Designation: E 12) of the American Society for Testing Materials,[1] shall be calculated from the following formula:

$$\text{Apparent specific gravity} = \frac{A}{A - C}$$

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 1436.

Absorption

8. The percentage of absorption shall be calculated from the following formula:

$$\text{Percentage of absorption} = \frac{B - A}{A} \times 100$$

Reproducibility of Results

9. Duplicate determinations should check to within 0.02 in the case of specific gravity and 0.05 per cent in the case of percentage of absorption.

TENTATIVE METHOD OF TEST

FOR

SPECIFIC GRAVITY AND ABSORPTION OF FINE AGGREGATE[1]

A.S.T.M. Designation: C 128 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1936.[2]

Scope

1. This method of test is intended for use in making determinations of bulk and apparent specific gravity, and absorption after 24 hr. in water at room temperature of fine aggregate. The bulk specific gravity is the value generally desired for calculations in connection with portland-cement concrete. The method determines directly the bulk specific gravity as defined in Section 4 of the Standard Definitions of Terms Relating to Specific Gravity (A.S.T.M. Designation: E 12) of the American Society for Testing Materials,[3] or the bulk specific gravity on the basis of weight of saturated surface-dry aggregate, or the apparent specific gravity as defined in Section 3 of the Standard Definitions E 12.[3]

Apparatus

2. The apparatus shall consist of the following:

(*a*) *Balance.*—A balance having a capacity of 1 kg. or more and sensitive to 0.1 g. or less.

(*b*) *Flask.*—A volumetric flask of 500-ml. capacity, calibrated to 0.1 ml. at 20 C.

(*c*) *Conical Mold.*—A metallic conical mold, $1\frac{1}{2}$ in. in diameter at the top, $3\frac{1}{2}$ in. in diameter at the bottom, and $2\frac{7}{8}$ in. in height.

(*d*) *Tamping Rod.*—A metal tamping rod, weighing 12 oz., and having a flat circular tamping face 1 in. in diameter.

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[1] Under the standardization procedure of the Society, this method is under the joint jurisdiction of the A.S.T.M. Committee C-9 on Concrete and Concrete Aggregates and Committee D-4 on Road and Paving Materials.

This method is in effect a revision and consolidation of, and replaces the former Standard Method of Test for Approximate Apparent Specific Gravity of Fine Aggregate (C 68 – 30) and the Standard Methods of Test for Apparent Specific Gravity of Sand, Stone, and Slag Screenings, and Other Fine Non-Bituminous Highway Materials (D 55 – 25), which methods were accordingly discontinued in 1936. The procedure for determining absorption in this method is in effect a tentative revision of, and will supersede when adopted as standard, the present Standard Method of Test for Absorption by Aggregates for Concrete (Laboratory Determinations) (C 95 – 36), 1936 Book of A.S.T.M. Standards, Part II, p. 330.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 26, 1936.

[3] 1936 Book of A.S.T.M. Standards, Part II, p. 1436.

Preparation of Sample

3. Approximately 1000 g. of the fine aggregate selected from the sample by the method of quartering shall be placed in a suitable pan or vessel, covered with water, and permitted to stand for 24 hr. The sample shall then be spread on a flat surface, exposed to a gently moving current of warm air, and stirred frequently to secure uniform drying. This operation shall be continued until the sand approaches a free flowing condition. The sand shall then be placed loosely in the conical mold, the surface lightly tamped 25 times with the metal rod, and the mold lifted vertically. If free moisture is present, the cone of sand will retain its shape. Drying with constant stirring shall be continued and tests made at frequent intervals, until the cone of sand slumps upon removal of the mold. This indicates that the sand has reached a surface-dry condition.

NOTE.—The procedure described in Section 3 is intended to insure that the first trial determination shall be made with some free water in the sample. If the cone of sand slumps on the first trial, the sand has been dried past the saturated and surface-dry condition. In this case a few milliliters of water shall be thoroughly mixed with the sand and the sample permitted to stand in a covered container for 30 min. The process of drying and testing the sand shall then be resumed.

Procedure

4. (*a*) A 500.0-g. sample of the material prepared as described in Section 3 shall be introduced immediately into the flask and the flask filled almost to the 500-ml. mark with water at a temperature of 20 C. The flask shall then be rolled on a flat surface to eliminate all air bubbles, after which it shall be placed in a constant temperature bath maintained at 20 C. After approximately 1 hr. it shall be filled with water to the 500-ml. mark and the total weight of water (Note) introduced into the flask shall be determined to the nearest 0.1 g.

NOTE.—If desired, the quantity of water necessary to fill the flask may be determined volumetrically by the use of a burette accurate to 0.1 ml.

(*b*) The fine aggregate shall be removed from the flask and dried to constant weight at a temperature of 100 to 110 C., cooled to room temperature in a desiccator, and weighed.

Bulk Specific Gravity

5. The bulk specific gravity as defined in Section 4 of the Standard Definitions of Terms Relating to Specific Gravity (A.S.T.M. Designation: E 12) of the American Society for Testing Materials,[1] shall be calculated from the following formula:

$$\text{Bulk specific gravity} = \frac{A}{V - W}$$

where A = weight in grams of dry sample in air,

V = volume in milliliters of flask, and

W = weight in grams or volume in milliliters of water added to flask.

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 1436.

Bulk Specific Gravity (Saturated Surface-Dry Basis)

6. The bulk specific gravity on the basis of weight of saturated surface-dry aggregate shall be calculated from the following formula:

$$\begin{array}{c}\text{Bulk specific gravity}\\ \text{(saturated surface-dry basis)}\end{array} = \frac{500}{V - W}$$

Apparent Specific Gravity

7. The apparent specific gravity as defined in Section 3 of the Standard Definitions of Terms Relating to Specific Gravity (A.S.T.M. Designation: E 12) of the American Society for Testing Materials,[1] shall be calculated from the following formula:

$$\text{Apparent specific gravity} = \frac{A}{(V - W) - (500 - A)}$$

Absorption

8. The percentage of absorption shall be calculated from the following formula:

$$\text{Percentage of absorption} = \frac{500 - A}{A} \times 100$$

Reproducibility of Results

9. Duplicate determinations should check to within 0.02 in the case of specific gravity and 0.05 per cent in the case of percentage of absorption.

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 1436.

TENTATIVE DEFINITIONS
OF
TERMS RELATING TO CONCRETE AND CONCRETE AGGREGATES[1]

A.S.T.M. Designation C 125 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1936.

Admixture.—In the case of concrete, a material other than cement, water and aggregate, mixed or to be mixed into concrete, or to any of the ingredients thereof.

Blast Furnace Slag.—The non-metallic product consisting essentially of silicates and alumino-silicates of lime, which is developed simultaneously with iron in a blast furnace.

Crushed Stone.—The product resulting from the artificial crushing of rocks, boulders or large cobblestones, substantially all faces of which have resulted from the crushing operation.

Fineness Modulus.—In the case of aggregate for concrete, an empirical factor obtained by adding the total percentages of a sample of the aggregate retained on each of a specified series of sieves, and dividing the sum by 100.

NOTE.—The sieve sizes used are Nos. 100, 50, 30, 16, 8 and 4, and $\frac{3}{8}$ in., $\frac{3}{4}$ in., $1\frac{1}{2}$ in. and larger, increasing in the ratio of 2 to 1.

Gravel.—The coarse granular material, larger than sand, resulting from the natural erosion of rock.

Crushed Gravel.—The product resulting from the artificial crushing of gravel with substantially all fragments having at least one face resulting from fracture.

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[1] Under the standardization procedure of the Society, these definitions are under the jurisdiction of the A.S.T.M. Committee C-9 on Concrete and Concrete Aggregates.

Approved as
AMERICAN TENTATIVE STANDARD
by the American Standards Association
A.S.A. NO.: M20.1-1936

TENTATIVE SPECIFICATIONS
FOR
CLASSIFICATION OF COALS BY RANK[1]

A.S.T.M. Designation: D 388 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934; REVISED, 1935, 1936.

Scope

1. These specifications cover the classification of coals by rank, that is, according to their degree of metamorphism, or progressive alteration, in the natural series from lignite to anthracite.

Basis of Classification

2. The basic scheme of classification is according to fixed carbon and calorific value (expressed in B.t.u.) calculated to the mineral-matter-free basis. The higher-rank coals are classified according to fixed carbon on the dry basis; and the lower-rank coals according to B.t.u. on the moist basis. Agglomerating and slacking indices are used to differentiate between certain adjacent groups.

CLASSIFICATION BY RANK

Classification by Rank

3. (*a*) *Fixed Carbon and B.t.u.*—Coals shall be classified by rank in accordance with Table I. Coals having calorific values of 14,000 B.t.u. or more on the moist, mineral-matter-free basis, and coals having fixed carbon of 69 per cent or more on the dry, mineral-matter-free basis, shall be classified according to fixed carbon on the dry, mineral-matter-free basis; coals having calorific values less than 14,000 B.t.u. on the moist, mineral-matter-free basis shall be classified according to B.t.u. on the moist, mineral-matter-free basis, provided the fixed carbon on the dry, mineral-matter-free basis is less than 69 per cent.

(*b*) *Weathering Index.*—Coals showing average weathering indices of less than 5 per cent shall be considered non-weathering, coals showing average weathering indices of 5 per cent or more shall be considered weathering from the standpoint of classification.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the Sectional Committee on Classification of Coals functioning under the procedure of the American Standards Association with the American Society for Testing Materials as sponsor.

(*c*) *Agglomerating Index.*—Coals which in the volatile matter determination produce either an agglomerate button that will support a 500-g. weight without pulverizing, or a button showing swelling or cell structure, shall be considered agglomerating from the standpoint of classification.

TABLE I.—CLASSIFICATION OF COALS BY RANK.

Legend: F.C. = Fixed Carbon. V.M. = Volatile Matter. B.t.u. = British thermal units

Class	Group	Limits of Fixed Carbon or B.t.u. Mineral-Matter-Free Basis	Requisite Physical Properties
I. Anthracitic	1. Meta-anthracite	Dry F.C., 98 per cent or more (Dry V.M., 2 per cent or less)	Non-agglomerating[a]
	2. Anthracite	Dry F.C., 92 per cent or more and less than 98 per cent (Dry V.M., 8 per cent or less and more than 2 per cent)	
	3. Semianthracite	Dry F.C., 86 per cent or more and less than 92 per cent (Dry V.M., 14 per cent or less and more than 8 per cent)	
II. Bituminous[c]	1. Low volatile bituminous coal	Dry F.C., 78 per cent or more and less than 86 per cent (Dry V.M., 22 per cent or less and more than 14 per cent)	
	2. Medium volatile bituminous coal	Dry F.C., 69 per cent or more and less than 78 per cent (Dry V.M., 31 per cent or less and more than 22 per cent)	
	3. High volatile *A* bituminous coal	Dry F.C., less than 69 per cent (Dry V.M., more than 31 per cent); and moist[b] B.t.u., 14,000[d] or more	
	4. High volatile *B* bituminous coal	Moist[b] B.t.u., 13,000 or more and less than 14,000[d]	
	5. High volatile *C* bituminous coal	Moist B.t.u., 11,000 or more and less than 13,000[d]	Either agglomerating or non-weathering[e]
III. Subbituminous	1. Subbituminous *A* coal	Moist B.t.u., 11,000 or more and less than 13,000[d]	Both weathering and non-agglomerating
	2. Subbituminous *B* coal	Moist B.t.u., 9500 or more and less than 11,000[d]	
	3. Subbituminous *C* coal	Moist B.t.u., 8300 or more and less than 9500[d]	
IV. Lignitic	1. Lignite	Moist B.t.u., less than 8300	Consolidated
	2. Brown coal	Moist B.t.u., less than 8300	Unconsolidated

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[a] If agglomerating, classify in low-volatile group of the bituminous class.

[b] Moist B.t.u. refers to coal containing its natural bed moisture but not including visible water on the surface of the coal.

[c] Pending the report of the Subcommittee on Origin and Composition and Methods of Analysis, it is recognized that there may be non-caking varieties in each group of the bituminous class.

[d] Coals having 69 per cent or more fixed carbon on the dry, mineral-matter-free basis shall be classified according to fixed carbon, regardless of B.t.u.

[e] There are three varieties of coal in the High-volatile *C* bituminous coal group, namely, Variety 1, agglomerating and non-weathering; Variety 2, agglomerating and weathering; Variety 3, non-agglomerating and non-weathering.

Symbols for Expressing Classification

4. (*a*) The position of a coal in the scale of rank may be expressed in condensed form as in the following example:

(62 — 146)

in which the parenthesis signifies that the contained numbers are on the mineral-matter-free basis. The first number represents fixed carbon on the dry basis, reported to the nearest whole per cent. The second number represents B.t.u. on the moist basis, expressed as hundreds of B.t.u. (to the nearest hundred); for example, 14,580 B.t.u. would be represented as 146.

(*b*) When agglomerating or weathering properties enter into the classification of a coal, they shall be expressed outside and immediately following the parenthesis by the following symbols:

ag. = agglomerating
na. = non-agglomerating
we. = weathering
nw. = non-weathering.

(*c*) Symbols describing the grade of coal shall be placed after the parenthesis, as shown in the following illustration:

(62–146) 132–A8–F24–S1.6

The numbers in parenthesis are on the mineral-matter-free basis, and give the position of the coal in the scale of rank as explained in Paragraph (*a*) of this section. The numbers and symbols following the parenthesis show the position of the coal according to classification by grade as shown in Section 2 of the Tentative Specifications for Classification of Coals by Grade (A.S.T.M. Designation: D 389 – 34 T) of the American Society for Testing Materials.[1] That is, 132–A8–F24–S1.6 indicates a heating value of approximately 13,200 B.t.u., an ash content of 6.1 to 8.0 per cent, inclusive, an ash-softening temperature of 2400 to 2590 F., inclusive, and a sulfur content of 1.4 to 1.6 per cent, inclusive, all expressed on the basis of the coal as sampled.

SAMPLING

Bed Samples

5. (*a*) The classification of a coal bed, or part of a coal bed, in any locality shall be based on the average analysis and calorific value (and agglomerating and weathering index where required) of not less than three and preferably five or more face samples taken in different and uniformly distributed localities, either within the same mine or closely adjacent mines representing a continuous and compact area not greater than approximately four square miles in regions of geological uniformity. In regions where conditions indicate that the coal probably varies rapidly in short distances the spacing of samples and grouping of analyses to provide average values shall not be such that coals of obviously different rank will be used in calculating average values.

(*b*) The samples shall be taken in accordance with the U. S. Bureau of Mines method[2] or its equivalent, and shall be placed in moisture-tight containers in the mine.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, p. 841 (1934); also 1936 Book of A.S.T.M. Tentative Standards, p. 527.

[2] J. A. Holmes, "The Sampling of Coal in the Mine," U. S. Bureau of Mines *Technical Paper No. 1* (1918).

(*c*) Analyses of samples from outcrops or from weathered or oxidized coal shall not be used for classification by rank.

(*d*) In case the coal is likely to be classified on the "moist" basis, that is, containing the natural bed-moisture, the samples shall be taken at freshly exposed faces, which are free from visible surface moisture if possible. Samples of low-rank coals which appear dry at the time of collection frequently give off moisture which condenses on the inner surface of the sample containers, before they are opened for analysis. In the case of coals which were free from visible surface moisture when sampled, but which show moisture on the inner surface of the containers when opened, both the container and the coal shall be weighed before and after air-drying and the total loss in weight shall be reported as air-drying loss.

(*e*) If it is impossible to sample the coal without including visible surface moisture, and the coal is likely to be classified on the "moist" basis, the sampler shall include the following statement in the description: "Sample contains surface moisture." Samples so marked shall not be used for classification on a moist basis unless brought to a standard condition of moisture equilibrium at 30 C. in a vacuum desiccator containing a saturated solution of potassium sulfate (97 per cent humidity) as suggested by Stansfield and Gilbart.[1] Analyses of such wet samples which have been treated in this manner shall be designated as "wet samples equilibrated at 30 C. and 97 per cent humidity."

Tipple or Shipment Samples

6. (*a*) The classification of "run of mine" coal and prepared sizes of coal shall be based on representative samples taken in accordance with the Standard Method of Sampling Coal (A.S.T.M. Designation: D 21) of the American Society for Testing Materials.[2]

(*b*) In case the coal is likely to be classified on the "moist" basis, the samples shall be taken at the tipple or preparation plant and protected against loss of moisture as specified in Sections 8 and 9 of the Standard Method D 21.[2] Samples which appear dry at the time of collection shall be handled in accordance with Section 5 (*d*) above to ensure correct determination of total air-drying loss. Samples which have visible surface moisture on the coal when sampled, and which are likely to be classified on the "moist" basis, shall be marked by the sampler, equilibrated, and the analyses designated in accordance with Section 5 (*e*) above.

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[1] Edgar Stansfield and K. C. Gilbart, "Moisture Determination for Coal Classification," *Transactions*, Am. Inst. Mining and Metallurgical Engrs., Coal Division, p. 125 (1932).

[2] 1936 Book of A.S.T.M. Standards, Part II, p. 382.

METHODS OF ANALYSIS AND TESTS

Laboratory Sampling and Analysis

7. The coal shall be prepared and analyzed in accordance with the Standard Methods of Laboratory Sampling and Analysis of Coal and Coke (A.S.T.M. Designation: D 271) of the American Society for Testing Materials.[1]

Weathering or Slacking Index

8. Pending the adoption of a method by the American Society for Testing Materials, the weathering or slacking characteristics of coals shall be determined by the U. S. Bureau of Mines method[2] modified with respect to the selection of a standard humidity. Briefly, the test consists of air-drying 500 to 1000 g. of approximately 1 to 1½ in. lumps at a temperature of 30 to 35 C. and a humidity of 30 to 35 per cent for a period of 24 hr. and then immersing the lumps in water for 1 hr.; the water then being drained off, and the sample again air-dried for 24 hr. The amount of disintegration is determined by sieving on an 8-in. wire-mesh sieve with 0.263-in. square openings, and weighing the quantity of coal passing (undersize) and that retained on (oversize) the sieve. The percentage of coal passing the sieve (undersize), after deducting a blank sieving test, is the weathering or slacking index of the coal.

Agglomerating Index

9. Pending the adoption of a method by the American Society for Testing Materials the coke-button grading test[3] afforded by the examination of the residue in the platinum crucible incident to the volatile matter determination, shall be used.

CALCULATION TO MINERAL-MATTER-FREE BASIS

Calculation of Fixed Carbon and B.t.u.

10. (*a*) For classification of coal according to rank, fixed carbon and B.t.u. shall be calculated to the mineral-matter-free basis in accordance with either the Parr formulas[4] (1), (2) and (3) or the approximation formulas (4), (5) and (6) given below. In case of litigation the appropriate Parr formula shall be used.

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 387.

[2] A. C. Fieldner, W. A. Selvig and W. H. Frederic, "Accelerated Laboratory Test for Determination of Slacking Characteristics of Coal," U. S. Bureau of Mines *Report of Investigations No. 3055* (1930).

[3] R. E. Gilmore, G. P. Connell and J. H. H. Nicolls, "Agglomerating and Agglutinating Tests for Classifying Weakly Caking Coals," *Transactions*, Am. Inst. Mining and Metallurgical Engrs., Coal Division, Vol. 108, p. 255 (1934).

[4] S. W. Parr, "The Classification of Coal," *Bulletin No. 180*, Engineering Experiment Station University of Illinois (1928).

Calculation from "moist" basis:

Parr Formulas:

$$\text{Dry, Mm-free F.C.} = \frac{\text{F.C.} - 0.15\text{S}}{100 - (\text{M} + 1.08\text{A} + 0.55\text{S})} \times 100 \qquad (1)$$

$$\text{Dry, Mm-free V.M.} = 100 - \text{Dry, Mm-free F.C.} \qquad (2)$$

$$\text{Moist, Mm-free B.t.u.} = \frac{\text{B.t.u.} - 50\text{S}}{100 - (1.08\text{A} + 0.55\text{S})} \times 100 \qquad (3)$$

NOTE.—The above formula for fixed carbon is derived from the Parr formula for volatile matter.

Approximation Formulas:

$$\text{Dry, Mm-free F.C.} = \frac{\text{F.C.}}{100 - (\text{M} + 1.1\text{A} + 0.1\text{S})} \times 100 \qquad (4)$$

$$\text{Dry, Mm-free V.M.} = 100 - \text{Dry, Mm-free F.C.} \qquad (5)$$

$$\text{Moist, Mm-free B.t.u.} = \frac{\text{B.t.u.}}{100 - (1.1\text{A} + 0.1\text{S})} \times 100 \qquad (6)$$

where:

Mm = mineral matter;
B.t.u. = British thermal units;
F.C. = percentage of fixed carbon;
V.M. = percentage of volatile matter;
M = percentage of moisture;
A = percentage of ash;
S = percentage of sulfur;

Moist refers to coal containing its natural bed moisture, but not including visible water on the surface of the coal. See Section 5 (*d*) and (*e*) and Section 6 (*b*) above.

Modification for Coals High in Carbonate

(*b*) In case of controversy, samples containing more than 1.0 per cent of carbon dioxide occurring as carbonates shall be either (1) crushed to pass through an 840-micron (No. 20) sieve and floated on a heavy liquid of such specific gravity as to reduce the carbon dioxide occurring as carbonate to 1.0 per cent or less on a dry basis, provided, however, that the recovery of float coal shall not be less than 75 per cent; or (2) shall be analyzed for mineral matter according to the Parr method[1] for coals with high calcium carbonate content. In case of litigation, method (1) shall be used.

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[1] S. W. Parr, "Chemical Study of Illinois Coal," Illinois Coal Mining Investigations, State Geological Survey, Urbana, Ill., *Bulletin No. 3*, p. 35 (1916).

APPENDIX

PUBLISHED ANALYSES SUITABLE FOR COAL CLASSIFICATION

Only such published analyses as have been made in accordance with the standard methods of the American Society for Testing Materials shall be used in the classification of coal; and if classification is on the basis of moist B.t.u., then only those samples which have been taken and transported to the laboratory in such a manner as to preserve the true moisture content of the coal shall be used. In general, the principal sources of published analyses of samples suitable for coal classification are the publications of the U. S. Bureau of Mines, the U. S. Geological Survey, and the Canadian Department of Mines. Suitable analyses are published also by some of the State Surveys and some of the Provinces of Canada. However, it must be kept in mind that many of the bed sample analyses of the governmental organizations are from prospects in which the coal may have been altered by exposure. Such samples shall not be used for classification. Analyses published prior to 1904 are unlikely to represent the true moisture content of coal, and even after this date, analyses from sources other than governmental laboratories are not likely to be representative with respect to moisture.

In view of the importance of the fixed carbon determination in coal classification, special attention is called to the 1913 revision in this method by the American Chemical Society.[1] The new revision was substantially the same as that introduced by the U. S. Bureau of Mines[2] a few years earlier, as a result of finding large discrepancies between results of the Pittsburgh, Pa., and Washington, D. C., laboratories. A considerable number of analyses were made before it was discovered that the natural-gas burners at the Pittsburgh laboratory gave high results for fixed carbon.[3] For this reason, the fixed carbon results of the U. S. Geological Survey or U. S. Bureau of Mines analyses designated by Laboratory Nos. 5147 to 9120, inclusive, shall not be used for the classification of coal.

All analyses made by any laboratory prior to 1913 should be rejected unless there is positive evidence that the methods of analysis were essentially those adopted by the American Society for Testing Materials in 1913.

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[1] Preliminary Report of the Committee on Coal Analysis of the American Society for Testing Materials and the American Chemical Society, *Journal of Industrial and Engineering Chemistry*, Vol. 5, p. 517 (1913); see also Report of Subcommittee IV on Volatile Matter, *Proceedings*, Am. Soc. Testing Mats., Vol. XIV, Part I, p. 424 (1914).

[2] A. C. Fieldner, "Notes on the Sampling and Analysis of Coal," U. S. Bureau of Mines *Technical Paper No. 76*, p. 16 (1914).

[3] N. W. Lord, J. A. Holmes, F. M. Stanton, A. C. Fieldner and S. Sanford, "Analyses of Coals in the United States," U. S. Bureau of Mines *Bulletin No. 22*, Part I, p. 28 (1913).

TENTATIVE METHOD FOR DESIGNATING THE SIZE OF COAL FROM ITS SCREEN ANALYSIS[1]

A.S.T.M. Designation: D 431 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1936.

Scope

1. (*a*) This method covers the designation of coal sizes from the results of screen analysis tests of samples taken to represent the condition of the coal as sold. The method applies only to natural continuous ranges of sizes as produced by mining, handling, crushing, screening, etc. In the case of special mixtures, or where the screen analysis indicates a substantial deviation from a normal gradation of sizes, a sufficiently complete screen analysis to properly describe the size composition shall be made and reported in accordance with the Tentative Method of Test for Screen Analysis of Coal (A.S.T.M. Designation: D 410 – 35 T) of the American Society for Testing Materials.[2]

(*b*) This method does not cover the standardization of screens used in the commercial preparation of coal.

Sampling and Screen Analysis

2. The sampling and screen analysis shall be performed in accordance with the Tentative Method of Test for Screen Analysis of Coal (A.S.T.M. Designation: D 410 – 35 T) of the American Society for Testing Materials.[2]

Screens

3. Size designations shall be in terms of screens of the following series:

(*a*) *Round-Hole Screens.*—Round-hole screens with 8, 6, 5, 4, 3, 2½, 2, 1½ 1¼, 1, ¾, ½, and ⅜-in. diameter openings, conforming to the Standard Specifications for Round-Hole Screens for Testing Purposes (A.S.T.M. Designation: E 17) of the American Society for Testing Materials.[3]

(*b*) *Sieves.*—Wire-cloth sieves with square openings, No. 4 (4760-micron), No. 8 (2380-micron), No. 16 (1190-micron), No. 30 (590-micron), No. 50 (297-micron), No. 100 (149-micron), and No. 200 (74-micron) sieves, conforming to the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials.[1]

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the Sectional Committee on Classification of Coals functioning under the procedure of the American Standards Association with the American Society for Testing Materials as sponsor.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 863 (1935); also 1936 Book of A.S.T.M. Tentative Standards, p. 541.

[3] 1936 Book of A.S.T.M. Standards, Part II, p. 1411.

Size Designation

4. The designation shall indicate the range of the size by giving the lower and upper limiting screens between which more than 80 per cent of the sample is retained by actual test, the limiting screens being selected as follows:

(*a*) The screen defining the lower limit shall be the largest screen of the series given in Section 3 through which passes a total of less than 15 per cent of the sample. The screen defining the upper limit shall be the smallest screen of the series given in Section 3 upon which is retained a total of less than 5 per cent of the sample.

(*b*) The terms for defining sizes shall be written with the lower limiting screen first, followed by a dash, and that followed by the upper limiting screen. The abbreviation "in." shall follow the upper limiting screen but may be omitted after the lower limiting screen. For screens of the U.S. standard sieve series (No. 4 and smaller), the abbreviation "No." shall be used each time a screen is indicated. If the total retained on the 8-in. screen is 5 per cent or greater, the size shall be designated by the lower limiting screen preceded by the word "plus" and followed by an expression in parenthesis giving the percentage over 8 in. to the nearest 1 per cent.

(*c*) The following examples illustrate the system of size designation:

Examples:

plus $\frac{1}{2}$ in. (10 per cent over 8 in.)
plus 4 in. (24 per cent over 8 in.)
plus No. 16 (6 per cent over 8 in.)
2 - 4 in.
$\frac{1}{2}$ - 3 in.
No. 4 - 2 in.
No. 30 - No. 4
No. 50 - 1 in.

NOTE 1.—On the basis of the relationship between square-mesh sieves and round-hole screens as determined by tests on coal, No. 4 sieve is roughly equivalent to $\frac{1}{4}$-in. round screen, No. 8 to $\frac{1}{8}$-in. round, No. 16 to $\frac{1}{16}$-in. round, and No. 30 to $\frac{1}{32}$-in. round.

NOTE 2.—Anthracite is commonly tested at the point of preparation or repreparation to determine whether the sizing conforms to the specifications of the Anthracite Institute by means of a series of special round-hole screens adopted by the Institute, none of which screens have the same size openings as the screens specified in Section 3 above. The methods of sampling and testing are given in the Standard Method of Test for Size of Anthracite (A.S.T.M. Designation: D 310) of the American Society for Testing Materials.[2]

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 1413.

[2] *Ibid.*, p. 432.

APPENDIX

CONDENSED SIZE DESIGNATION

For some purposes, the following condensed system of size designation with fewer sizes and less precision may be found convenient. This condensed system is published as information only, as the procedure prescribed in Section 4 shall be the standard method for designating the sizes of coal.

The condensed system provides for designating the limiting screens as defined in Section 4, as follows:

LIMITING SCREENS	CONDENSED SIZE DESIGNATIONS
8 in	8
6 in	6
5 in	5
4 in	4
2½ in., 3 in	3
1½ in., 2 in	2
¾ in., 1 in., 1¼ in	1
No. 4, ⅜ in., ½ in	½
As lower limiting screens only: No. 8, No. 16, No. 30, No. 50, No. 100, No. 200	0, provided that there are at least three screens of the series between the two limiting screens.[1]

Sizes are designated by the above condensed size designations, or combinations of two of them to include the designations of the upper and lower limiting screens as defined under Section 4, the lower limit being written first. Coals containing 5 per cent or more over the 8-in. screen are designated by the number for the lower limiting screen preceded by the word "plus." The percentage over the 8-in. screen is omitted under this condensed scheme. The following examples illustrate the system of condensed size designation:

Examples:

STANDARD SIZE DESIGNATION	CONDENSED SIZE DESIGNATION
¾ – 1¼ in	1
2½ – 3 in	3
2 – 4 in	24
1¼ – 2½ in	13
3 – 6 in	36
⅜ – 1¼ in	½ 1
plus 2 in. (14 per cent over 8 in.)	plus 2
plus No. 8 (7 per cent over 8 in.)	plus 0
No. 16 – 2 in	02
No. 50 – ½ in	0 ½

If the lower limiting screen is smaller than No. 4 and there are fewer than three screens between the two limiting screens, the standard size designation is used.

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[1] A number of run-of-mine and slack coals, for which screen-test results are available, all have more than three screens of the standard series between the two limiting screens as defined by Section 4.

Whenever the upper limiting screen is smaller than No. 4, the size is designated by giving the two limits with a dash between, using 0 for the lower limit whenever indicated by the condensed system.

Examples:

STANDARD SIZE DESIGNATION	CONDENSED SIZE DESIGNATION
No. 30 – No. 8	No. 30 – No. 8
No. 100 – No. 8	0 – No. 8

TENTATIVE SPECIFICATIONS

FOR

STRUCTURAL WOOD JOIST AND PLANK, BEAMS AND STRINGERS, AND POSTS AND TIMBERS

A.S.T.M. Designation: D 245 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1926; ADOPTED IN AMENDED FORM, 1927; REVISED, 1930, 1933; REISSUED IN AMENDED FORM AS TENTATIVE, 1936.

GENERAL REQUIREMENTS

Applying to All Stress-Grades and Items

Manufacture

1. All material shall be well-manufactured.

Quality of Wood

2. No piece of exceptionally light weight is permitted.

Decay

3. Only pieces consisting of sound wood, free from any form of decay are acceptable, unless otherwise specified.

Slope of Grain

4. Slope of grain shall be measured over a distance sufficiently great to determine the general slope disregarding slight local deviations. Within the middle half of length of piece, slope of grain shall not be steeper than specified.

Holes

5. Knot holes and holes from causes other than knots are measured and limited as provided for knots.

Cluster Knots

6. Cluster knots and knots in groups are not permitted.

Knots in Joist and Plank

7. (*a*) *Knots on Narrow Faces.*—Size of knot on a narrow face is taken as width between lines enclosing knot and parallel to edges of piece. The only knots measured on narrow faces, except spike knots which cross the corners of side-cut pieces, are those that do not show on wide faces.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-7 on Timber.

These specifications were prepared jointly by the American Railway Engineering Association and the American Society for Testing Materials.

These specifications are in effect a revision of, and replace the former Standard Specifications for Structural Wood Joist and **Planks, Beams** and **Stringers,** and Posts and Timbers (A.S.T.M. Designation: D 245-33) of the American Society for Testing Materials, which standard was accordingly discontinued in 1936.

(*b*) *Knots on Wide Faces.*—Size of knot on a wide face is the average of its largest and smallest diameters. A spike knot which crosses a corner of a side-cut piece and contains the intersection of the adjacent faces, or which extends entirely across a face of a piece, shall be measured only on its end or ends, between lines parallel to the edges of the piece.

(*c*) *Permissible Increase in Knot Sizes.*—Size of knots on narrow faces and at edges of wide faces may increase proportionately from size permitted in middle third of length to twice that size at ends of piece. Size of knots on wide faces may increase proportionately from size permitted at edge to size permitted along center line.

(*d*) *Sum of Knots.*—Sum of sizes of all knots within middle half of length of any face, measured as specified by Paragraph (*a*) or (*b*) for the face under consideration, shall not exceed four and one-half times the size of largest knot allowed on that face.

Knots in Beams and Stringers

8. (*a*) *Knots on Narrow Faces.*—Size of knot on a narrow face is taken as width between lines enclosing knot and parallel to edges of piece except that when a knot on a narrow face extends into the adjacent one-fourth of the width of a wide face its least dimension is taken as its size.

(*b*) *Knots on Wide Faces.*—Size of knot on a wide face is its smallest diameter. Knots at edges of wide faces are limited to same sizes as on narrow faces but are measured according to this paragraph.

(*c*) *Permissible Increase in Knot Size.*—Size of knots on narrow faces and at edges of wide faces may increase proportionately from size permitted in middle third of length to twice that size at ends of piece, except that size of no knot shall exceed size permitted along center line of wide face. Size of knots on wide faces may increase proportionately from size permitted at edge to size permitted along center line.

(*d*) *Sum of Knots.*—Sum of sizes of all knots within middle half of length of any face, measured as specified by Paragraph (*a*) or (*b*) for the face under consideration, shall not exceed four times the size of largest knot allowed on that face.

Knots in Posts and Timbers

9. (*a*) *Knots on Either Face.*—Size of a knot is half the sum of its largest and smallest diameters. A spike knot which crosses a corner of a side-cut piece and contains the intersection of the adjacent faces, or which extends entirely across a face of a piece, shall be measured only on its end or ends, between lines parallel to the edges of the piece.

(*b*) *Sum of Knots.*—Sum of sizes of all knots in any 6 in. of the length of piece, measured as specified by Paragraph (*a*), is not permitted to exceed twice the maximum permissible size of knot. Two knots of maximum permissible size are not allowed in same 6 in. of length on any face.

Shakes, Checks, Splits in Joist and Plank and Beams and Stringers

10. (*a*) Shakes, checks and splits, where permitted in the grade specified later in these specifications, are measured at ends of piece. Only those within middle half of height are considered. (Height equals width of wide face.) Size of shake is distance between lines enclosing shake and parallel to wide faces of piece. Permissible size is determined by width of narrow face of piece.

(*b*) Checks and splits are measured and limited in same way as shakes. The following limitations apply to both ends but only within middle half of height of piece and within three times height from end. (Height equals width of wide face.) Size of checks within this portion of piece shall be taken as their estimated area, along horizontal section showing maximum area, divided by three times height of piece (Note). When checks on two parallel faces are opposite or approximately so, sum of their sizes is taken. Sum of sizes of shakes, checks, and/or splits shall not exceed permissible size of shake.

(*c*) Checks extending entirely across end within middle half of height shall not extend into piece at center of width of end a distance greater than size of allowable shake.

Shakes, Checks, Splits in Posts and Timbers

11. (*a*) Shakes, checks and splits, where permitted in the grade specified later in these specifications, are measured at the ends of the piece. Size of a shake is distance between lines enclosing shake and parallel to a pair of opposite faces.

(*b*) Checks and splits are measured and limited in the same way as shakes. Size of checks within three times width of piece from either end shall be taken as their estimated area, along the longitudinal section showing maximum area, divided by three times width of piece (Note). Sum of sizes of shakes, checks, and/or splits shall not exceed the permissible size of shake.

(*c*) Checks extending entirely across end shall not extend into piece at center of width of end, a distance greater than size of allowable shake.

NOTE.—A practical method of inspection in the field to determine the size of checks and splits under the above specification is as follows:

The size of checks within the specified portion of the piece shall be taken as the sum of seven depth measurements, one on the end and three on each side, divided by three. Each measurement shall represent the greatest depth of *any* check within the center half of the height; the measurement on the end shall be taken at the center of the width, and the three measurements on each side shall be taken at distances of one, two, and three times the height of the piece from the end in joist, plank, beams and stringers, and the width of the piece from the end in posts and timbers. Each measurement shall be determined by the penetration into the piece of a probe $\frac{1}{64}$ in. in thickness and $\frac{1}{4}$ in. in width.

OPTIONAL AND ADDITIONAL REQUIREMENTS

Applying to Stress-Grades when Heartwood or Wane, and Where Density and Close Grain Are Required

Heartwood Requirements

12. Where heartwood material is desired it shall be specified in terms of the amount or percentage of heartwood on the girth, or on each face, side or edge, measured at the point where the greatest amount of sapwood occurs.

For all timber to be pressure treated there shall be no heartwood requirement and the amount of sapwood shall not be limited.

Wane

13. Where wane is not desired, the specifications should state "Square Edge."

Density (where required)

14. (*a*) *Dense Douglas Fir.*—Shall average on either one end or the other of each piece not less than six annual rings per inch in Douglas Fir, and, in addition, one-third or more summerwood (the dark portion of the annual ring) measured over 3 in. on a line at a right angle to the annual rings, located as described below. The contrast in color between summerwood and springwood shall be distinct.

Coarse-grained material excluded by this rule shall be accepted as dense if averaging one-half or more summerwood.

In boxed-heart pieces the line shall run from the pith to the corner farthest from the pith except, when the line is not representative, it shall be shifted sufficiently to present a fair average but the distance from the pith to the beginning of the 3-in. portion of the line shall not be changed. When the least dimension is 6 in. or less, the 3-in. portion of the line shall begin at a distance of 1 in. from the pith. When the least dimension is more than 6 in., the 3-in. portion of the line shall begin at a distance from the pith equal to one-fourth the least dimension of the piece.

In side-cut pieces (pith not present) the center of the 3-in. portion of the line shall be at the center of the end of the piece.

If a 3-in. portion of the line cannot be obtained, the measurement shall be made over as much of a 3-in. portion as is available.

In case of disagreement, two radial lines shall be chosen and the summerwood and number of rings shall be taken as the average on these lines.

(*b*) *Dense Longleaf or Shortleaf Yellow Pine.*—Shall average on either one end or the other of each piece not less than six annual rings per inch, and, in addition, one-third or more summerwood (the darker, harder portion of the annual ring), measured over the third, fourth, and fifth inches of a radial line from the pith. The contrast in color between summerwood and springwood shall be sharp and the summerwood shall be dark in color, except in pieces having considerably above the minimum requirement for summerwood.

Coarse-grained material excluded by this rule shall be accepted as dense if averaging one-half or more summerwood.

The radial line shall be representative of the average growth of the cross section. In case of disagreement, two radial lines shall be chosen, and the number of rings per inch and percentage of summerwood shall be taken as the average determined on these lines.

In boxed-heart pieces the measurement shall be made over the third, fourth, and fifth inches from the pith along the radial line.

In material containing the pith, but not a 5-in. radial line, which is less than 2 by 8 in. in section or less than 8 in. in width, that does not show over 16 sq. in. on the cross section, the inspection shall apply to the second inch from the pith. In larger material that does not show a 5-in. radial line, the inspection shall apply to the three inches farthest from the pith.

In cases where timbers do not contain the pith and it is impossible to locate it with any degree of accuracy, the same inspection shall be made over 3 in. on an approximate radial line beginning at the edge nearest the pith in timbers over 3 in. in thickness and on the second inch nearest the pith in timbers 3 in. or less in thickness.

Close Grain (where required)

15. *Close-Grained Douglas Fir, or Redwood.*—Shall average on either one end or the other of each piece not less than six nor more than twenty annual rings per inch in Douglas fir, or not less than ten nor more than thirty-five annual rings per inch in redwood, measured over 3 in. on a line at right angle to the annual rings located as described below.

In boxed-heart pieces the line shall run from the pith to the corner farthest from the pith except, when the line is not representative, it shall be shifted sufficiently to present a fair average but the distance from the pith to the beginning of the 3-in. portion of the line shall not be changed. When the least dimension is 6 in. or less, the 3-in. portion of the line shall begin at a distance of 1 in. from the pith. When the least dimension is more than 6 in., the 3-in. portion of the line shall begin at a distance from the pith equal to one-fourth the least dimension of the piece.

In side-cut pieces (pith not present) the center of the 3-in. portion of the line shall be at the center of the end of the piece.

If a 3-in. portion of the line cannot be obtained, the measurement shall be made over as much of a 3-in. portion as is available.

In case of disagreement, two radial lines shall be chosen and the number of rings shall be taken as the average on these lines.

Pieces of Douglas fir averaging five rings or more than twenty shall be accepted if containing one-third or more summerwood.

STRESS-GRADES

I. JOIST AND PLANK

f = Extreme fiber stress in bending in pounds per square inch for continuously dry locations.

1800 lb. f Structural Joist and Plank

DENSE DOUGLAS FIR (COAST REGION)
DENSE DOUGLAS FIR (INLAND)
DENSE LONGLEAF SOUTHERN PINE
DENSE SHORTLEAF SOUTHERN PINE

Slope of Grain.—1 in 12.

Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	ON NARROW FACE, OR AT EDGE OF WIDE FACE, MIDDLE THIRD OF LENGTH		AT CENTER LINE OF WIDE FACE
2	$\frac{5}{8}$ in.	On Narrow Face	......
3	1 in.		......
4	$1\frac{1}{4}$ in.		......
4	$\frac{3}{4}$ in.	At Edge of Wide Face	$1\frac{1}{4}$ in.
6	1 in.		$1\frac{7}{8}$ in.
8	$1\frac{3}{8}$ in.		$2\frac{1}{2}$ in.
10	$1\frac{3}{4}$ in.		$3\frac{1}{4}$ in.
12	$2\frac{1}{8}$ in.		$3\frac{7}{8}$ in.
14	$2\frac{1}{4}$ in.		$4\frac{1}{8}$ in.
16	$2\frac{1}{2}$ in.		$4\frac{1}{2}$ in.

Shakes, Checks, Splits:	WIDTH OF NARROW FACE When Green	When Seasoned
120 lb. Shear Grade (Fir)	$\frac{1}{6}$	$\frac{1}{4}$
120 lb. Shear Grade (Pine)	$\frac{3}{16}$	$\frac{3}{8}$
Wane	$\frac{1}{6}$ Width of any face	

1600 lb. f Structural Joist and Plank

CLOSE-GRAINED DOUGLAS FIR (COAST REGION)

Slope of Grain.—1 in 12.

Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	ON NARROW FACE, OR AT EDGE OF WIDE FACE, MIDDLE THIRD OF LENGTH		AT CENTER LINE OF WIDE FACE
2	$\frac{5}{8}$ in.	On Narrow Face	......
3	1 in.		......
4	$1\frac{1}{4}$ in.		......
4	$\frac{3}{4}$ in.	At Edge of Wide Face	$1\frac{1}{4}$ in.
6	1 in.		$1\frac{7}{8}$ in.
8	$1\frac{3}{8}$ in.		$2\frac{1}{2}$ in.
10	$1\frac{3}{4}$ in.		$3\frac{1}{4}$ in.
12	$2\frac{1}{8}$ in.		$3\frac{7}{8}$ in.
14	$2\frac{1}{4}$ in.		$4\frac{1}{8}$ in.
16	$2\frac{1}{2}$ in.		$4\frac{1}{2}$ in.

Shakes, Checks, Splits:	WIDTH OF NARROW FACE When Green	When Seasoned
100 lb. Shear Grade	$\frac{1}{6}$	$\frac{1}{4}$
Wane	$\frac{1}{6}$ Width of any face	

1600 lb. *f*. Structural Joist and Plank (*Continued*)

DENSE LONGLEAF SOUTHERN PINE
DENSE SHORTLEAF SOUTHERN PINE

Slope of Grain.—1 in 12.

Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	ON NARROW FACE, OR AT EDGE OF WIDE FACE, MIDDLE THIRD OF LENGTH		AT CENTER LINE OF WIDE FACE
2	$\frac{3}{4}$ in.	On	......
3	$1\frac{1}{8}$ in.	Narrow	......
4	$1\frac{1}{2}$ in.	Face	......
4	$\frac{7}{8}$ in.		$1\frac{1}{2}$ in.
6	$1\frac{1}{4}$ in.	At	$2\frac{1}{4}$ in.
8	$1\frac{5}{8}$ in.	Edge	3 in.
10	$2\frac{1}{8}$ in.	of	$3\frac{3}{4}$ in.
12	$2\frac{1}{2}$ in.	Wide	$4\frac{1}{2}$ in.
14	$2\frac{3}{4}$ in.	Face	$4\frac{7}{8}$ in.
16	$2\frac{7}{8}$ in.		$5\frac{1}{8}$ in.

Shakes, Checks, Splits:

	WIDTH OF NARROW FACE	
	When Green	When Seasoned
120 lb. Shear Grade	$\frac{3}{16}$	$\frac{3}{8}$
Wane	$\frac{1}{5}$ Width of any face	

CLOSE-GRAINED REDWOOD

Slope of Grain.—1 in 16.

Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	ON NARROW FACE, OR AT EDGE OF WIDE FACE, MIDDLE THIRD OF LENGTH		AT CENTER LINE OF WIDE FACE
2	$\frac{3}{8}$ in.	On	......
3	$\frac{5}{8}$ in.	Narrow	......
4	$\frac{7}{8}$ in.	Face	......
4	$\frac{3}{8}$ in.		$\frac{7}{8}$ in.
6	$\frac{5}{8}$ in.	At	$1\frac{1}{4}$ in.
8	$\frac{7}{8}$ in.	Edge	$1\frac{3}{4}$ in.
10	$1\frac{1}{8}$ in.	of	$2\frac{1}{8}$ in.
12	$1\frac{1}{4}$ in.	Wide	$2\frac{1}{2}$ in.
14	$1\frac{3}{8}$ in.	Face	$2\frac{3}{4}$ in.
16	$1\frac{1}{2}$ in.		3 in.

Shakes, Checks, Splits:

	WIDTH OF NARROW FACE	
	When Green	When Seasoned
80 lb. Shear Grade	$\frac{1}{7}$	$\frac{2}{5}$
Wane	$\frac{1}{8}$ Width of any face	

1400 lb. *f* Structural Joist and Plank

TIDEWATER RED CYPRESS

Slope of Grain.—1 in 14.

Knots and Peck.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	ON NARROW FACE, OR AT EDGE OF WIDE FACE, MIDDLE THIRD OF LENGTH		AT CENTER LINE OF WIDE FACE
2	$\frac{5}{8}$ in.	On	......
3	$\frac{7}{8}$ in.	Narrow	......
4	$1\frac{1}{8}$ in.	Face	......
4	$\frac{5}{8}$ in.		$1\frac{1}{8}$ in.
6	1 in.	At	$1\frac{3}{4}$ in.
8	$1\frac{1}{4}$ in.	Edge	$2\frac{3}{8}$ in.
10	$1\frac{5}{8}$ in.	of	$2\frac{7}{8}$ in.
12	$1\frac{7}{8}$ in.	Wide	$3\frac{1}{2}$ in.
14	2 in.	Face	$3\frac{3}{4}$ in.
16	$2\frac{1}{4}$ in.		$4\frac{1}{8}$ in.

Shakes, Checks, Splits:

	WIDTH OF NARROW FACE	
	When Green	When Seasoned
120 lb. Shear Grade	$\frac{1}{10}$	$\frac{1}{5}$
Wane	$\frac{1}{6}$ Width of any face	

1400 lb. *f* Structural Joist and Plank (*Continued*)

OAK

Slope of Grain.—1 in 12.

Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	ON NARROW FACE, OR AT EDGE OF WIDE FACE, MIDDLE THIRD OF LENGTH		AT CENTER LINE OF WIDE FACE
2	$\frac{5}{8}$ in.	On Narrow Face	......
3	1 in.		......
4	$1\frac{3}{8}$ in.		......
4	$\frac{3}{4}$ in.	At Edge of Wide Face	$1\frac{1}{4}$ in.
6	$1\frac{1}{8}$ in.		2 in.
8	$1\frac{1}{2}$ in.		$2\frac{5}{8}$ in.
10	$1\frac{7}{8}$ in.		$3\frac{1}{4}$ in.
12	$2\frac{1}{4}$ in.		4 in.
14	$2\frac{3}{8}$ in.		$4\frac{1}{4}$ in.
16	$2\frac{1}{2}$ in.		$4\frac{5}{8}$ in.

	WIDTH OF NARROW FACE When Green	WIDTH OF NARROW FACE When Seasoned
Shakes, Checks, Splits:		
120 lb. Shear Grade	$\frac{1}{4}$	$\frac{1}{3}$
Wane	$\frac{1}{8}$ Width of any face	

DENSE LONGLEAF SOUTHERN PINE

Slope of Grain.—1 in 10.

Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	ON NARROW FACE, OR AT EDGE OF WIDE FACE, MIDDLE THIRD OF LENGTH		AT CENTER LINE OF WIDE FACE
2	$\frac{7}{8}$ in.	On Narrow Face	......
3	$1\frac{1}{4}$ in.		......
4	$1\frac{3}{4}$ in.		......
4	1 in.	At Edge of Wide Face	$1\frac{3}{4}$ in.
6	$1\frac{1}{2}$ in.		$2\frac{5}{8}$ in.
8	2 in.		$3\frac{1}{2}$ in.
10	$2\frac{1}{2}$ in.		$4\frac{1}{4}$ in.
12	3 in.		$5\frac{1}{4}$ in.
14	$3\frac{1}{4}$ in.		$5\frac{5}{8}$ in.
16	$3\frac{3}{8}$ in.		6 in.

	WIDTH OF NARROW FACE When Green	WIDTH OF NARROW FACE When Seasoned
Shakes, Checks, Splits:		
100 lb. Shear Grade	$\frac{4}{10}$	$\frac{4}{9}$
Wane	$\frac{1}{4}$ Width of any face	

CLOSE-GRAINED REDWOOD

Slope of Grain.—1 in 14.

Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	ON NARROW FACE, OR AT EDGE OF WIDE FACE, MIDDLE THIRD OF LENGTH		AT CENTER LINE OF WIDE FACE
2	$\frac{1}{2}$ in.	On Narrow Face	......
3	$\frac{7}{8}$ in.		......
4	$1\frac{1}{8}$ in.		......
4	$\frac{5}{8}$ in.	At Edge of Wide Face	$1\frac{1}{8}$ in.
6	$\frac{7}{8}$ in.		$1\frac{5}{8}$ in.
8	$1\frac{1}{4}$ in.		$2\frac{1}{4}$ in.
10	$1\frac{1}{2}$ in.		$2\frac{7}{8}$ in.
12	$1\frac{7}{8}$ in.		$3\frac{3}{8}$ in.
14	2 in.		$3\frac{5}{8}$ in.
16	$2\frac{1}{8}$ in.		$3\frac{7}{8}$ in.

	WIDTH OF NARROW FACE When Green	WIDTH OF NARROW FACE When Seasoned
Shakes, Checks, Splits:		
80 lb. Shear Grade	$\frac{1}{7}$	$\frac{2}{9}$
Wane	$\frac{1}{6}$ Width of any face	

1200 lb. *f* Structural Joist and Plank

PORT ORFORD CEDAR

Slope of Grain.—1 **in** 14.

Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	ON NARROW FACE, OR AT EDGE OF WIDE FACE, MIDDLE THIRD OF LENGTH		AT CENTER LINE OF WIDE FACE
2	½ in.	On	......
3	⅞ in.	Narrow	......
4	1⅛ in.	Face	......
4	⅝ in.		1⅛ in.
6	⅞ in.	At	1⅝ in.
8	1¼ in.	Edge	2¼ in.
10	1½ in.	of	2⅞ in.
12	1⅞ in.	Wide	3⅜ in.
14	2 in.	Face	3⅝ in.
16	2⅛ in.		3⅞ in.

	WIDTH OF NARROW FACE	
Shakes, Checks, Splits:	When Green	When Seasoned
100 lb. Shear Grade	⅙	¼

Wane.. ⅛ Width of any face

DOUGLAS FIR (COAST REGION)

Slope of Grain.—1 in 10.

Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	ON NARROW FACE, OR AT EDGE OF WIDE FACE, MIDDLE THIRD OF LENGTH		AT CENTER LINE OF WIDE FACE
2	⅞ in.	On	......
3	1¼ in.	Narrow	......
4	1¾ in.	Face	......
4	1 in.		1¾ in.
6	1½ in.	At	2⅝ in.
8	2 in.	Edge	3½ in.
10	2½ in.	of	4¼ in.
12	3 in.	Wide	5¼ in.
14	3¼ in.	Face	5⅝ in.
16	3⅜ in.		6 in.

	WIDTH OF NARROW FACE	
Shakes, Checks, Splits:	When Green	When Seasoned
100 lb. Shear Grade	⅙	¼

Wane.. ¼ Width of any face

DENSE SHORTLEAF SOUTHERN PINE

Slope of Grain.—1 in 8.

Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	ON NARROW FACE, OR AT EDGE OF WIDE FACE, MIDDLE THIRD OF LENGTH		AT CENTER LINE OF WIDE FACE
2	1 in.	On	......
3	1½ in.	Narrow	......
4	2 in.	Face	......
4	1⅛ in.		2 in.
6	1¾ in.	At	3 in.
8	2¼ in.	Edge	3⅞ in.
10	2⅞ in.	of	4⅞ in.
12	3½ in.	Wide	5⅞ in.
14	3¾ in.	Face	6⅜ in.
16	4 in.		6⅞ in.

	WIDTH OF NARROW FACE	
Shakes, Checks, Splits:	When Green	When Seasoned
100 lb. Shear Grade	$\frac{1}{10}$	⅛

Wane.. ¼ Width of any face

1200 lb. *f* Structural Joist and Plank (*Continued*)

CLOSE-GRAINED REDWOOD

Slope of Grain.—1 in 12.

Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	ON NARROW FACE, OR AT EDGE OF WIDE FACE, MIDDLE THIRD OF LENGTH		AT CENTER LINE OF WIDE FACE
2	$\frac{3}{4}$ in.	On Narrow Face	......
3	$1\frac{1}{8}$ in.		......
4	$1\frac{1}{2}$ in.		......
4	$\frac{7}{8}$ in.	At Edge of Wide Face	$1\frac{3}{8}$ in.
6	$1\frac{1}{4}$ in.		$2\frac{1}{8}$ in.
8	$1\frac{5}{8}$ in.		$2\frac{7}{8}$ in.
10	2 in.		$3\frac{5}{8}$ in.
12	$2\frac{3}{8}$ in.		$4\frac{3}{8}$ in.
14	$2\frac{5}{8}$ in.		$4\frac{3}{4}$ in.
16	$2\frac{3}{4}$ in.		5 in.

	WIDTH OF NARROW FACE When Green	WIDTH OF NARROW FACE When Seasoned
Shakes, Checks, Splits:		
70 lb. Shear Grade	$\frac{1}{4}$	$\frac{1}{3}$

Wane.......... $\frac{1}{5}$ Width of any face

1100 lb. *f* Structural Joist and Plank

PORT ORFORD CEDAR

Slope of Grain.—1 in 12.

Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	ON NARROW FACE, OR AT EDGE OF WIDE FACE, MIDDLE THIRD OF LENGTH		AT CENTER LINE OF WIDE FACE
2	$\frac{5}{8}$ in.	On Narrow Face	......
3	1 in.		......
4	$1\frac{3}{8}$ in.		......
4	$\frac{3}{4}$ in.	At Edge of Wide Face	$1\frac{1}{4}$ in.
6	$1\frac{1}{8}$ in.		2 in.
8	$1\frac{1}{2}$ in.		$2\frac{5}{8}$ in.
10	$1\frac{7}{8}$ in.		$3\frac{1}{4}$ in.
12	$2\frac{1}{4}$ in.		4 in.
14	$2\frac{3}{8}$ in.		$4\frac{1}{4}$ in.
16	$2\frac{1}{2}$ in.		$4\frac{5}{8}$ in.

	WIDTH OF NARROW FACE When Green	WIDTH OF NARROW FACE When Seasoned
Shakes, Checks, Splits:		
80 lb. Shear Grade	$\frac{1}{3}$	$\frac{4}{10}$

Wane.......... $\frac{1}{6}$ Width of any face

TIDEWATER RED CYPRESS

Slope of Grain.—1 in 10.

Knots and Peck.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	ON NARROW FACE, OR AT EDGE OF WIDE FACE, MIDDLE THIRD OF LENGTH		AT CENTER LINE OF WIDE FACE
2	$\frac{3}{4}$ in.	On Narrow Face	......
3	$1\frac{1}{4}$ in.		......
4	$1\frac{5}{8}$ in.		......
4	$\frac{7}{8}$ in.	At Edge of Wide Face	$1\frac{5}{8}$ in.
6	$1\frac{3}{8}$ in.		$2\frac{1}{2}$ in.
8	$1\frac{7}{8}$ in.		$3\frac{1}{4}$ in.
10	$2\frac{3}{8}$ in.		$4\frac{1}{8}$ in.
12	$2\frac{3}{4}$ in.		5 in.
14	3 in.		$5\frac{3}{8}$ in.
16	$3\frac{1}{4}$ in.		$5\frac{3}{4}$ in.

	WIDTH OF NARROW FACE When Green	WIDTH OF NARROW FACE When Seasoned
Shakes, Checks, Splits:		
100 lb. Shear Grade	$\frac{1}{4}$	$\frac{1}{3}$

Wane.......... $\frac{1}{4}$ Width of any face

1100 lb. *f* Structural Joist and Plank (*Continued*)

OAK

Slope of Grain.—1 in 10.

Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	ON NARROW FACE, OR AT EDGE OF WIDE FACE, MIDDLE THIRD OF LENGTH		AT CENTER LINE OF WIDE FACE
2	$\frac{7}{8}$ in.	On Narrow Face	......
3	$1\frac{3}{8}$ in.		......
4	$1\frac{3}{4}$ in.		......
4	1 in.	At Edge of Wide Face	$1\frac{3}{4}$ in.
6	$1\frac{1}{2}$ in.		$2\frac{5}{8}$ in.
8	2 in.		$3\frac{1}{2}$ in.
10	$2\frac{1}{2}$ in.		$4\frac{3}{8}$ in.
12	3 in.		$5\frac{1}{4}$ in.
14	$3\frac{1}{4}$ in.		$5\frac{3}{4}$ in.
16	$3\frac{1}{2}$ in.		$6\frac{1}{8}$ in.

	WIDTH OF NARROW FACE When Green	WIDTH OF NARROW FACE When Seasoned
Shakes, Checks, Splits:		
100 lb. Shear Grade	$\frac{4}{10}$	$\frac{3}{8}$
Wane	$\frac{1}{4}$ Width of any face	

1000 lb. *f* Structural Joist and Plank

WESTERN RED CEDAR

Slope of Grain.—1 in 14.

Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	ON NARROW FACE, OR AT EDGE OF WIDE FACE, MIDDLE THIRD OF LENGTH		AT CENTER LINE OF WIDE FACE
2	$\frac{1}{2}$ in.	On Narrow Face	......
3	$\frac{7}{8}$ in.		......
4	$1\frac{1}{8}$ in.		......
4	$\frac{5}{8}$ in.	At Edge of Wide Face	$1\frac{1}{8}$ in.
6	$\frac{7}{8}$ in.		$1\frac{5}{8}$ in.
8	$1\frac{1}{4}$ in.		$2\frac{1}{4}$ in.
10	$1\frac{1}{2}$ in.		$2\frac{3}{4}$ in.
12	$1\frac{3}{4}$ in.		$3\frac{3}{8}$ in.
14	2 in.		$3\frac{5}{8}$ in.
16	$2\frac{1}{8}$ in.		$3\frac{7}{8}$ in.

	WIDTH OF NARROW FACE When Green	WIDTH OF NARROW FACE When Seasoned
Shakes, Checks, Splits:		
100 lb. Shear Grade	$\frac{1}{18}$	$\frac{1}{6}$
Wane	$\frac{1}{6}$ Width of any face	

II. STRUCTURAL BEAMS AND STRINGERS

f = Extreme fiber stress in bending in pounds per square inch for continuously dry locations.

1800 lb. *f* Structural Beams and Stringers

DENSE DOUGLAS FIR (COAST REGION)	DENSE LONGLEAF SOUTHERN PINE
DENSE DOUGLAS FIR (INLAND)	DENSE SHORTLEAF SOUTHERN PINE

Slope of Grain.—1 in 16.

Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	ON NARROW FACE, MIDDLE THIRD OF LENGTH	AT CENTER LINE OF WIDE FACE
5	$1\frac{1}{8}$ in.	......
6	$1\frac{3}{8}$ in.	......
8	$1\frac{5}{8}$ in.	$1\frac{7}{8}$ in.
10	$1\frac{3}{4}$ in.	$2\frac{1}{4}$ in.
12	$1\frac{7}{8}$ in.	$2\frac{5}{8}$ in.
14	$2\frac{1}{8}$ in.	$2\frac{7}{8}$ in.
16	$2\frac{1}{4}$ in.	$3\frac{1}{8}$ in.
18	......	$3\frac{3}{8}$ in.
20	......	$3\frac{1}{2}$ in.

	WIDTH OF NARROW FACE When Green	WIDTH OF NARROW FACE When Seasoned
Shakes, Checks, Splits:		
120 lb. Shear Grade (Fir)	$\frac{1}{6}$	$\frac{1}{4}$
120 lb. Shear Grade (Pine)	$\frac{3}{10}$	$\frac{3}{8}$
Wane	$\frac{1}{8}$ Width of any face	

1600 lb. *f* Structural Beams and Stringers

CLOSE-GRAINED DOUGLAS FIR (COAST REGION)

Slope of Grain.—1 in 15.

Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	ON NARROW FACE, MIDDLE THIRD OF LENGTH	AT CENTER LINE OF WIDE FACE
5	$1\frac{1}{8}$ in.	......
6	$1\frac{3}{8}$ in.	......
8	$1\frac{5}{8}$ in.	$1\frac{7}{8}$ in.
10	$1\frac{3}{4}$ in.	$2\frac{1}{4}$ in.
12	$1\frac{7}{8}$ in.	$2\frac{5}{8}$ in.
14	$2\frac{1}{8}$ in.	$2\frac{7}{8}$ in.
16	$2\frac{1}{4}$ in.	$3\frac{1}{8}$ in.
18	......	$3\frac{3}{8}$ in.
20	......	$3\frac{1}{2}$ in.

	WIDTH OF NARROW FACE	
Shakes, Checks, Splits:	When Green	When Seasoned
100 lb. Shear Grade	$\frac{1}{6}$	$\frac{1}{4}$
Wane	$\frac{1}{6}$ Width of any face	

DENSE LONGLEAF SOUTHERN PINE
DENSE SHORTLEAF SOUTHERN PINE

Slope of Grain.—1 in 12.

Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	ON NARROW FACE, MIDDLE THIRD OF LENGTH	AT CENTER LINE OF WIDE FACE
5	$1\frac{1}{2}$ in.	......
6	$1\frac{7}{8}$ in.	......
8	$2\frac{1}{8}$ in.	$2\frac{1}{2}$ in.
10	$2\frac{3}{8}$ in.	$3\frac{1}{8}$ in.
12	$2\frac{5}{8}$ in.	$3\frac{3}{4}$ in.
14	$2\frac{7}{8}$ in.	4 in.
16	3 in.	$4\frac{3}{8}$ in.
18	......	$4\frac{5}{8}$ in.
20	......	$4\frac{7}{8}$ in.

	WIDTH OF NARROW FACE	
Shakes, Checks, Splits:	When Green	When Seasoned
120 lb. Shear Grade	$\frac{3}{10}$	$\frac{3}{8}$
Wane	$\frac{1}{6}$ Width of any face	

CLOSE-GRAINED REDWOOD

Slope of Grain.—1 in 20.

Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	ON NARROW FACE, MIDDLE THIRD OF LENGTH	AT CENTER LINE OF WIDE FACE
5	$\frac{3}{8}$ in.	......
6	$\frac{3}{8}$ in.	......
8	$\frac{1}{2}$ in.	$\frac{1}{2}$ in.
10	$\frac{1}{2}$ in.	$\frac{5}{8}$ in.
12	$\frac{5}{8}$ in.	$\frac{3}{4}$ in.
14	$\frac{5}{8}$ in.	$\frac{7}{8}$ in.
16	$\frac{3}{4}$ in.	$\frac{7}{8}$ in.
18	......	1 in.
20	......	1 in.

	WIDTH OF NARROW FACE	
Shakes, Checks, Splits:	When Green	When Seasoned
80 lb. Shear Grade	$\frac{1}{7}$	$\frac{2}{9}$
Wane	$\frac{1}{10}$ Width of any face	

1400 lb. *f* Structural Beams and Stringers

TIDEWATER RED CYPRESS

Slope of Grain.—1 in 16.

Knots and Peck.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	ON NARROW FACE, MIDDLE THIRD OF LENGTH	AT CENTER LINE OF WIDE FACE
5	1 in.	......
6	$1\frac{1}{8}$ in.	......
8	$1\frac{3}{8}$ in.	$1\frac{1}{2}$ in.
10	$1\frac{1}{2}$ in.	$1\frac{7}{8}$ in.
12	$1\frac{5}{8}$ in.	$2\frac{1}{4}$ in.
14	$1\frac{3}{4}$ in.	$2\frac{1}{2}$ in.
16	$1\frac{7}{8}$ in.	$2\frac{5}{8}$ in.
18	......	$2\frac{7}{8}$ in.
20	......	3 in.

Shakes, Checks, Splits:	WIDTH OF NARROW FACE When Green	WIDTH OF NARROW FACE When Seasoned
120 lb. Shear Grade	$\frac{1}{10}$	$\frac{1}{8}$
Wane	$\frac{1}{8}$ Width of any face	

OAK

Slope of Grain.—1 in 15.

Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	ON NARROW FACE, MIDDLE THIRD OF LENGTH	AT CENTER LINE OF WIDE FACE
5	$1\frac{1}{4}$ in.	......
6	$1\frac{1}{2}$ in.	......
8	$1\frac{3}{4}$ in.	2 in.
10	2 in.	$2\frac{1}{2}$ in.
12	$2\frac{1}{8}$ in.	3 in.
14	$2\frac{1}{4}$ in.	$3\frac{1}{4}$ in.
16	$2\frac{1}{2}$ in.	$3\frac{1}{2}$ in.
18	......	$3\frac{3}{4}$ in.
20	......	$3\frac{7}{8}$ in.

Shakes, Checks, Splits:	WIDTH OF NARROW FACE When Green	WIDTH OF NARROW FACE When Seasoned
120 lb. Shear Grade	$\frac{1}{4}$	$\frac{1}{3}$
Wane	$\frac{1}{6}$ Width of any face	

DENSE LONGLEAF SOUTHERN PINE

Slope of Grain.—1 in 10.

Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	ON NARROW FACE, MIDDLE THIRD OF LENGTH	AT CENTER LINE OF WIDE FACE
5	2 in.	......
6	$2\frac{3}{8}$ in.	......
8	$2\frac{3}{4}$ in.	$3\frac{1}{4}$ in.
10	$3\frac{1}{8}$ in.	4 in.
12	$3\frac{3}{8}$ in.	$4\frac{7}{8}$ in.
14	$3\frac{5}{8}$ in.	$5\frac{1}{4}$ in.
16	4 in.	$5\frac{5}{8}$ in.
18	......	$5\frac{7}{8}$ in.
20	......	$6\frac{1}{4}$ in.

Shakes, Checks, Splits:	WIDTH OF NARROW FACE When Green	WIDTH OF NARROW FACE When Seasoned
100 lb. Shear Grade	$\frac{4}{10}$	$\frac{4}{8}$
Wane	$\frac{1}{4}$ Width of any face	

1400 lb. *f* Structural Beams and Stringers (*Continued*)

CLOSE-GRAINED REDWOOD

Slope of Grain.—1 in 18.

Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	ON NARROW FACE, MIDDLE THIRD OF LENGTH	AT CENTER LINE OF WIDE FACE
5	$\frac{7}{8}$ in.	......
6	$1\frac{1}{8}$ in.	......
8	$1\frac{1}{4}$ in.	$1\frac{1}{2}$ in.
10	$1\frac{3}{8}$ in.	$1\frac{3}{4}$ in.
12	$1\frac{1}{2}$ in.	$2\frac{1}{4}$ in.
14	$1\frac{5}{8}$ in.	$2\frac{3}{8}$ in.
16	$1\frac{3}{4}$ in.	$2\frac{1}{2}$ in.
18	......	$2\frac{3}{4}$ in.
20	......	$2\frac{3}{4}$ in.

Shakes, Checks, Splits:	WIDTH OF NARROW FACE When Green	WIDTH OF NARROW FACE When Seasoned
80 lb. Shear Grade	$\frac{1}{7}$	$\frac{2}{9}$
Wane	$\frac{1}{8}$ Width of any face	

1200 lb. *f* Structural Beams and Stringers

DENSE SHORTLEAF SOUTHERN PINE

Slope of Grain.—1 in 8.

Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	ON NARROW FACE, MIDDLE THIRD OF LENGTH	AT CENTER LINE OF WIDE FACE
5	$2\frac{3}{8}$ in.	......
6	$2\frac{7}{8}$ in.	......
8	$3\frac{3}{8}$ in.	$3\frac{7}{8}$ in.
10	$3\frac{3}{4}$ in.	$4\frac{7}{8}$ in.
12	$4\frac{1}{8}$ in.	$5\frac{3}{4}$ in.
14	$4\frac{3}{8}$ in.	$6\frac{1}{4}$ in.
16	$4\frac{3}{4}$ in.	$6\frac{3}{4}$ in.
18	......	$7\frac{1}{8}$ in.
20	......	$7\frac{1}{2}$ in.

Shakes, Checks, Splits:	WIDTH OF NARROW FACE When Green	WIDTH OF NARROW FACE When Seasoned
100 lb. Shear Grade	$\frac{4}{10}$	$\frac{4}{9}$
Wane	$\frac{1}{4}$ Width of any face	

CLOSE-GRAINED REDWOOD

Slope of Grain.—1 in 14.

Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	ON NARROW FACE, MIDDLE THIRD OF LENGTH	AT CENTER LINE OF WIDE FACE
5	$1\frac{1}{2}$ in.	......
6	$1\frac{3}{4}$ in.	......
8	$2\frac{1}{8}$ in.	$2\frac{3}{8}$ in.
10	$2\frac{3}{8}$ in.	3 in.
12	$2\frac{5}{8}$ in.	$3\frac{5}{8}$ in.
14	$2\frac{3}{4}$ in.	$3\frac{7}{8}$ in.
16	3 in.	$4\frac{1}{4}$ in.
18	......	$4\frac{1}{2}$ in.
20	......	$4\frac{3}{4}$ in.

Shakes, Checks, Splits:	WIDTH OF NARROW FACE When Green	WIDTH OF NARROW FACE When Seasoned
70 lb. Shear Grade	$\frac{1}{4}$	$\frac{1}{3}$
Wane	$\frac{1}{6}$ Width of any face	

1100 lb. *f* Structural Beams and Stringers

PORT ORFORD CEDAR

Slope of Grain.—1 in 15.

Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	ON NARROW FACE, MIDDLE THIRD OF LENGTH	AT CENTER LINE OF WIDE FACE
5	1¼ in.	......
6	1½ in.	......
8	1¾ in.	2 in.
10	2 in.	2½ in.
12	2⅛ in.	3 in.
14	2¼ in.	3¼ in.
16	2½ in.	3½ in.
18	......	3¾ in.
20	......	3⅞ in.

Shakes, Checks, Splits:	WIDTH OF NARROW FACE When Green	 When Seasoned
80 lb. Shear Grade	$\frac{1}{3}$	$\frac{4}{10}$
Wane	$\frac{1}{6}$ Width of any face	

TIDEWATER RED CYPRESS

Slope of Grain.—1 in 12.

Knots and Peck.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	ON NARROW FACE, MIDDLE THIRD OF LENGTH	AT CENTER LINE OF WIDE FACE
5	1¾ in.	......
6	2⅛ in.	......
8	2½ in.	2⅞ in.
10	2¾ in.	3⅝ in.
12	3⅛ in.	4⅜ in.
14	3⅜ in.	4¾ in.
16	3½ in.	5 in.
18	......	5⅜ in.
20	......	5⅝ in.

Shakes, Checks, Splits:	WIDTH OF NARROW FACE When Green	 When Seasoned
100 lb. Shear Grade	$\frac{1}{4}$	$\frac{1}{3}$
Wane	$\frac{1}{5}$ Width of any face	

OAK

Slope of Grain.—1 in 10.

Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	ON NARROW FACE, MIDDLE THIRD OF LENGTH	AT CENTER LINE OF WIDE FACE
5	2 in.	......
6	2½ in.	......
8	2⅞ in.	3¼ in.
10	3¼ in.	4⅛ in.
12	3½ in.	5 in.
14	3¾ in.	5⅜ in.
16	4 in.	5¾ in.
18	......	6 in.
20	......	6⅜ in.

Shakes, Checks, Splits:	WIDTH OF NARROW FACE When Green	 When Seasoned
100 lb. Shear Grade	$\frac{4}{10}$	$\frac{4}{9}$
Wane	$\frac{1}{4}$ Width of any face	

1000 lb. *f* Structural Beams and Stringers

WESTERN RED CEDAR

Slope of Grain.—1 in 18.

Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	ON NARROW FACE, MIDDLE THIRD OF LENGTH	AT CENTER LINE OF WIDE FACE
5	$\frac{3}{4}$ in.	......
6	1 in.	......
8	$1\frac{1}{8}$ in.	$1\frac{3}{8}$ in.
10	$1\frac{1}{4}$ in.	$1\frac{5}{8}$ in.
12	$1\frac{3}{8}$ in.	2 in.
14	$1\frac{1}{2}$ in.	$2\frac{1}{8}$ in.
16	$1\frac{5}{8}$ in.	$2\frac{1}{4}$ in.
18	......	$2\frac{3}{8}$ in.
20	......	$2\frac{1}{2}$ in.

	WIDTH OF NARROW FACE When Green	WIDTH OF NARROW FACE When Seasoned
Shakes, Checks, Splits:		
100 lb. Shear Grade	$\frac{1}{8}$	$\frac{1}{6}$
Wane	$\frac{1}{8}$ Width of any face	

III. STRUCTURAL POSTS AND TIMBERS

c = Compression stress parallel to grain in pounds per square inch for continuously dry locations.

1300 lb. *c* Structural Posts and Timbers

DENSE DOUGLAS FIR (COAST REGION) DENSE LONGLEAF SOUTHERN PINE
DENSE DOUGLAS FIR (INLAND) DENSE SHORTLEAF SOUTHERN PINE

Slope of Grain.—1 in 12.

Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	AT ANY POINT ON ANY FACE
5	$1\frac{1}{4}$ in.
6	$1\frac{1}{2}$ in.
8	$1\frac{7}{8}$ in.
10	$2\frac{3}{8}$ in.
12	$2\frac{7}{8}$ in.
14	$3\frac{1}{8}$ in.
16	$3\frac{3}{8}$ in.
18	$3\frac{1}{2}$ in.
20	$3\frac{3}{4}$ in.

	WIDTH OF NARROW FACE When Green	WIDTH OF NARROW FACE When Seasoned
Shakes, Checks, Splits	$\frac{4}{10}$	$\frac{1}{2}$
Wane	$\frac{1}{8}$ Width of any face	

1200 lb. *c* Structural Posts and Timbers

TIDEWATER RED CYPRESS

Slope of Grain.—1 in 12.

Knots and Peck.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	AT ANY POINT ON ANY FACE
5	$\frac{7}{8}$ in.
6	$1\frac{1}{8}$ in.
8	$1\frac{1}{2}$ in.
10	$1\frac{3}{4}$ in.
12	$2\frac{1}{4}$ in.
14	$2\frac{3}{8}$ in.
16	$2\frac{1}{2}$ in.
18	$2\frac{3}{4}$ in.
20	$2\frac{3}{4}$ in.

	WIDTH OF NARROW FACE When Green	WIDTH OF NARROW FACE When Seasoned
Shakes, Checks, Splits	$\frac{1}{3}$	$\frac{4}{9}$
Wane	$\frac{1}{8}$ Width of any face	

1200 lb. *c* Structural Posts and Timbers (*Continued*)

CLOSE-GRAINED DOUGLAS FIR (COAST REGION)

Slope of Grain.—1 in 12.

Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	AT ANY POINT ON ANY FACE
5	$1\frac{1}{8}$ in.
6	$1\frac{3}{8}$ in.
8	$1\frac{7}{8}$ in.
10	$2\frac{3}{8}$ in.
12	$2\frac{3}{4}$ in.
14	3 in.
16	$3\frac{1}{4}$ in.
18	$3\frac{3}{8}$ in.
20	$3\frac{5}{8}$ in.

	WIDTH OF NARROW FACE When Green	 When Seasoned
Shakes, Checks, Splits	$\frac{4}{10}$	$\frac{1}{2}$
Wane	$\frac{1}{8}$ Width of any face	

DENSE LONGLEAF SOUTHERN PINE
DENSE SHORTLEAF SOUTHERN PINE

Slope of Grain.—1 in 10.

Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	AT ANY POINT ON ANY FACE
5	$1\frac{1}{2}$ in.
6	$1\frac{3}{4}$ in.
8	$2\frac{3}{8}$ in.
10	3 in.
12	$3\frac{5}{8}$ in.
14	$3\frac{7}{8}$ in.
16	$4\frac{1}{4}$ in.
18	$4\frac{1}{2}$ in.
20	$4\frac{3}{4}$ in.

	WIDTH OF NARROW FACE When Green	 When Seasoned
Shakes, Checks, Splits	$\frac{4}{10}$	$\frac{1}{2}$
Wane	$\frac{1}{6}$ Width of any face	

CLOSE-GRAINED REDWOOD

Slope of Grain.—1 in 14.

Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	AT ANY POINT ON ANY FACE
5	$\frac{3}{4}$ in.
6	$\frac{7}{8}$ in.
8	$1\frac{1}{4}$ in.
10	$1\frac{1}{2}$ in.
12	$1\frac{7}{8}$ in.
14	2 in.
16	$2\frac{1}{8}$ in.
18	$2\frac{1}{4}$ in.
20	$2\frac{3}{8}$ in.

	WIDTH OF NARROW FACE When Green	 When Seasoned
Shakes, Checks, Splits	$\frac{1}{3}$	$\frac{4}{9}$
Wane	$\frac{1}{8}$ Width of any face	

1100 lb. *c* Structural Posts and Timbers

DOUGLAS FIR (COAST REGION)

Slope of Grain.—1 in 12.
Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	AT ANY POINT ON ANY FACE
5	1¼ in.
6	1½ in.
8	2 in.
10	2½ in.
12	3 in.
14	3¼ in.
16	3½ in.
18	3¾ in.
20	3⅞ in.

	WIDTH OF NARROW FACE	
	When Green	When Seasoned
Shakes, Checks, Splits	4/10	½
Wane	⅙ Width of any face	

OAK

Slope of Grain.—1 in 14.
Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	AT ANY POINT ON ANY FACE
5	⅞ in.
6	1 in.
8	1⅜ in.
10	1¾ in.
12	2⅛ in.
14	2¼ in.
16	2⅜ in.
18	2½ in.
20	2⅝ in.

	WIDTH OF NARROW FACE	
	When Green	When Seasoned
Shakes, Checks, Splits	⅓	3/7
Wane	⅛ Width of any face	

CLOSE-GRAINED REDWOOD

Slope of Grain.—1 in 12.
Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	AT ANY POINT ON ANY FACE
5	1⅛ in.
6	1⅜ in.
8	1¾ in.
10	2¼ in.
12	2⅝ in.
14	2⅞ in.
16	3⅛ in.
18	3¼ in.
20	3½ in.

	WIDTH OF NARROW FACE	
	When Green	When Seasoned
Shakes, Checks, Splits	⅜	½
Wane	⅛ Width of any face	

1000 lb. *c* Structural Posts and Timbers

PORT ORFORD CEDAR

Slope of Grain.—1 in 14.
Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	AT ANY POINT ON ANY FACE
5	7/8 in.
6	1 in.
8	1 3/8 in.
10	1 5/8 in.
12	2 in.
14	2 1/8 in.
16	2 1/4 in.
18	2 3/8 in.
20	2 1/2 in.

	WIDTH OF NARROW FACE When Green	WIDTH OF NARROW FACE When Seasoned
Shakes, Checks, Splits	1/3	3/7
Wane	1/8 Width of any face	

TIDEWATER RED CYPRESS

Slope of Grain.—1 in 10.
Knots and Peck.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	AT ANY POINT ON ANY FACE
5	1 5/8 in.
6	1 7/8 in.
8	2 1/2 in.
10	3 1/4 in.
12	3 3/4 in.
14	4 in.
16	4 3/8 in.
18	4 3/4 in.
20	5 in.

	WIDTH OF NARROW FACE When Green	WIDTH OF NARROW FACE When Seasoned
Shakes, Checks, Splits	4/9	5/8
Wane	1/6 Width of any face	

OAK

Slope of Grain.—1 in 12.
Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	AT ANY POINT ON ANY FACE
5	1 1/4 in.
6	1 1/2 in.
8	2 in.
10	2 1/2 in.
12	3 in.
14	3 1/4 in.
16	3 1/2 in.
18	3 3/4 in.
20	3 7/8 in.

	WIDTH OF NARROW FACE When Green	WIDTH OF NARROW FACE When Seasoned
Shakes, Checks, Splits	4/10	1/2
Wane	1/6 Width of any face	

1000 lb. *c* Structural Posts and Timbers (*Continued*)

DENSE LONGLEAF SOUTHERN PINE

Slope of Grain.—1 in 8.
Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	AT ANY POINT ON ANY FACE
5	$2\frac{1}{8}$ in.
6	$2\frac{1}{2}$ in.
8	$3\frac{3}{8}$ in.
10	$4\frac{1}{8}$ in.
12	5 in.
14	$5\frac{3}{8}$ in.
16	$5\frac{3}{4}$ in.
18	$6\frac{1}{8}$ in.
20	$6\frac{3}{8}$ in.

	WIDTH OF NARROW FACE When Green	 When Seasoned
Shakes, Checks, Splits	$\frac{1}{2}$	$\frac{5}{8}$
Wane	$\frac{1}{4}$ Width of any face	

CLOSE-GRAINED REDWOOD

Slope of Grain.—1 in 10.
Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	AT ANY POINT ON ANY FACE
5	$1\frac{1}{2}$ in.
6	$1\frac{3}{4}$ in.
8	$2\frac{3}{8}$ in.
10	$2\frac{7}{8}$ in.
12	$3\frac{1}{2}$ in.
14	$3\frac{3}{4}$ in.
16	$4\frac{1}{5}$ in.
18	$4\frac{3}{8}$ in.
20	$4\frac{5}{8}$ in.

	WIDTH OF NARROW FACE When Green	 When Seasoned
Shakes, Checks, Splits	$\frac{3}{7}$	$\frac{1}{2}$
Wane	$\frac{1}{6}$ Width of any face	

900 lb. *c* Structural Posts and Timbers

PORT ORFORD CEDAR

Slope of Grain.—1 in 12.
Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	AT ANY POINT ON ANY FACE
5	$1\frac{1}{4}$ in.
6	$1\frac{1}{2}$ in.
8	2 in.
10	$2\frac{1}{2}$ in.
12	3 in.
14	$3\frac{1}{4}$ in.
16	$3\frac{1}{2}$ in.
18	$3\frac{3}{4}$ in.
20	$3\frac{7}{8}$ in.

	WIDTH OF NARROW FACE When Green	 When Seasoned
Shakes, Checks, Splits	$\frac{4}{10}$	$\frac{1}{2}$
Wane	$\frac{1}{8}$ Width of any face	

900 lb. *c* Structural Posts and Timbers (*Continued*)

DENSE SHORTLEAF SOUTHERN PINE

Slope of Grain.—1 in 6.
Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	AT ANY POINT ON ANY FACE
5	$2\frac{3}{8}$ in.
6	$2\frac{7}{8}$ in.
8	$3\frac{3}{4}$ in.
10	$4\frac{3}{4}$ in.
12	$5\frac{5}{8}$ inl
14	$6\frac{1}{8}$ in.
16	$6\frac{1}{2}$ in.
18	7 in.
20	$7\frac{1}{4}$ in.

	WIDTH OF NARROW FACE	
	When Green	When Seasoned
Shakes, Checks, Splits	$\frac{5}{9}$	$\frac{2}{3}$
Wane	$\frac{1}{4}$ Width of any face	

800 lb. *c* Posts and Timbers

WESTERN RED CEDAR

Slope of Grain.—1 in 14.
Knots.—Maximum permissible size in inches:

NOMINAL WIDTH OF FACE, IN.	AT ANY POINT ON ANY FACE
5	$\frac{3}{4}$ in.
6	$\frac{3}{4}$ in.
8	$1\frac{1}{8}$ in.
10	$1\frac{3}{8}$ in.
12	$1\frac{3}{4}$ in.
14	$1\frac{7}{8}$ in.
16	2 in.
18	$2\frac{1}{8}$ in.
20	$2\frac{1}{4}$ in.

	WIDTH OF NARROW FACE	
	When Green	When Seasoned
Shakes, Checks, Splits	$\frac{3}{10}$	$\frac{3}{8}$
Wane	$\frac{1}{8}$ Width of any face	

(See Appendix appearing on page 844)

APPENDIX

The following three tables summarizing standard sizes, stress-grades and working stresses for joist and plank, beams and stringers, and posts and timbers are appended for information. They offer a valuable key to different structural grades.

TABLE I.—STANDARD SIZES, STRESS-GRADES, AND WORKING STRESSES FOR STRUCTURAL JOIST AND PLANK.

Standard Sizes

Nominal thicknesses	2, 3 and 4 in.
Permissible minimum rough thicknesses in not to exceed 20 per cent of pieces in any one shipment:	
2 in.	$\frac{1}{8}$ in. off
3 and 4 in.	$\frac{3}{16}$ in. off
Dressed thicknesses, S1S or S2S	$\frac{3}{8}$ in. off
Nominal widths	4 in. and wider
Permissible minimum rough widths in not to exceed 20 per cent of pieces in any one shipment:	
4 and 6 in.	$\frac{3}{16}$ in. off
8 in. and wider	$\frac{1}{4}$ in. off
Dressed widths, S1E or S2E:	
4 and 6 in.	$\frac{3}{8}$ in. off
8 in. and wider	$\frac{1}{2}$ in. off

Standard Stress-Grades and Working Stresses

(Continuously Dry Locations)

GRADES AND SPECIES	FIBER STRESS IN BENDING OR TENSION, LB. PER SQ. IN.	MAXIMUM HORIZONTAL SHEAR, LB.	COMPRESSION PERPENDICULAR TO GRAIN, LB.	MODULUS OF ELASTICITY, LB. PER SQ. IN.
1800 lb. *f* Dense Douglas Fir (Coast and Inland)	1800	120	380	1 600 000
1800 lb. *f* Dense Longleaf or Dense Shortleaf Southern Pine	1800	120	380	1 600 000
1600 lb. *f* Close-Grained Douglas Fir (Coast)	1600	100	345	1 600 000
1600 lb. *f* Dense Longleaf or Dense Shortleaf Southern Pine	1600	120	380	1 600 000
1600 lb. *f* Close-Grained Redwood	1600	80	267	1 200 000
1400 lb. *f* Tidewater Red Cypress	1400	120	300	1 200 000
1400 lb. *f* Oak	1400	120	500	1 500 000
1400 lb. *f* Dense Longleaf Southern Pine	1400	100	380	1 600 000
1400 lb. *f* Close-Grained Redwood	1400	80	267	1 200 000
1200 lb. *f* Port Orford Cedar	1200	100	250	1 200 000
1200 lb. *f* Douglas Fir (Coast)	1200	100	325	1 600 000
1200 lb. *f* Dense Shortleaf Southern Pine	1200	100	380	1 600 000
1200 lb. *f* Close-Grained Redwood	1200	70	267	1 200 000
1100 lb. *f* Port Orford Cedar	1100	80	250	1 200 000
1100 lb. *f* Tidewater Red Cypress	1100	100	300	1 200 000
1100 lb. *f* Oak	1100	100	500	1 500 000
1000 lb. *f* Western Red Cedar	1000	100	200	1 000 000

TABLE II.—STANDARD SIZES, STRESS-GRADES, AND WORKING STRESSES FOR STRUCTURAL BEAMS AND STRINGERS.

Standard Sizes

Nominal thicknesses	5 in. and thicker
Permissible minimum rough thicknesses in not to exceed 20 per cent of pieces in any one shipment:	
5 and 6 in.	$\frac{3}{16}$ in. off
8 in. and wider	$\frac{1}{4}$ in. off
Dressed thicknesses, S1S or S2S	$\frac{1}{2}$ in. off
Nominal widths	8 in. and wider
Permissible minimum rough widths in not to exceed 20 per cent of pieces in any one shipment	$\frac{1}{4}$ in. off
Dressed widths, S1E or S2E	$\frac{1}{2}$ in. off

Standard Stress-Grades and Working Stresses

(Continuously Dry Locations)

GRADES AND SPECIES	FIBER STRESS IN BENDING OR TENSION, LB. PER SQ. IN.	MAXIMUM HORIZONTAL SHEAR, LB.	COMPRESSION PERPENDICULAR TO GRAIN, LB.	MODULUS OF ELASTICITY, LB. PER SQ. IN.
1800 lb. *f* Dense Douglas Fir (Coast and Inland)	1800	120	380	1 600 000
1800 lb. *f* Dense Longleaf or Dense Shortleaf Southern Pine	1800	120	380	1 600 000
1600 lb. *f* Close-Grained Douglas Fir (Coast)	1600	100	345	1 600 000
1600 lb. *f* Dense Longleaf or Dense Shortleaf Southern Pine	1600	120	380	1 600 000
1600 lb. *f* Close-Grained Redwood.	1600	80	267	1 200 000
1400 lb. *f* Tidewater Red Cypress.	1400	120	300	1 200 000
1400 lb. *f* Oak	1400	120	500	1 500 000
1400 lb. *f* Dense Longleaf Southern Pine	1400	100	380	1 600 000
1400 lb. *f* Close-Grained Redwood.	1400	80	267	1 200 000
1200 lb. *f* Dense Shortleaf Southern Pine	1200	100	380	1 600 000
1200 lb. *f* Close-Grained Redwood.	1200	70	267	1 200 000
1100 lb. *f* Port Orford Cedar	1100	80	250	1 200 000
1100 lb. *f* Tidewater Red Cypress.	1100	100	300	1 200 000
1100 lb. *f* Oak	1100	100	500	1 500 000
1000 lb. *f* Western Red Cedar	1000	100	200	1 000 000

TABLE III.—STANDARD SIZES, STRESS-GRADES, AND WORKING STRESSES FOR STRUCTURAL POSTS AND TIMBERS.

Standard Sizes:

Nominal thicknesses	5 in. and thicker
Permissible minimum rough thicknesses in not to exceed 20 per cent of pieces in any one shipment:	
5 and 6 in.	$\frac{3}{16}$ in. off
8 in. and wider	$\frac{1}{4}$ in. off
Dressed thicknesses, S1S or S2S	$\frac{1}{2}$ in. off
Nominal widths	5 in. and wider
Permissible minimum rough widths in not to exceed 20 per cent of pieces in any one shipment:	
5 and 6 in.	$\frac{3}{16}$ in. off
8 in. and wider	$\frac{1}{4}$ in. off
Dressed widths, S1E or S2E	$\frac{1}{2}$ in. off

Standard Stress-Grades and Working Stresses

(Continuously Dry Locations)

GRADES AND SPECIES	COMPRESSION PARALLEL TO GRAIN, SHORT COLUMNS, LB. PER SQ. IN.	
1300 lb. *c* Dense Douglas Fir (Coast and Inland)	1300	
1300 lb. *c* Dense Longleaf or Dense Shortleaf Southern Pine	1300	
1200 lb. *c* Tidewater Red Cypress	1200	
1200 lb. *c* Close-Grained Douglas Fir (Coast)	1200	For stresses in compression perpendicular to grain and modulus of elasticity, see values in Table II for Beams and Stringers.
1200 lb. *c* Dense Longleaf or Dense Shortleaf Southern Pine	1200	
1200 lb. *c* Close-Grained Redwood	1200	
1100 lb. *c* Douglas Fir (Coast)	1100	
1100 lb. *c* Oak	1100	
1100 lb. *c* Close-Grained Redwood	1100	
1000 lb. *c* Port Orford Cedar	1000	
1000 lb. *c* Tidewater Red Cypress	1000	
1000 lb. *c* Oak	1000	
1000 lb. *c* Dense Longleaf Southern Pine	1000	
1000 lb. *c* Close-Grained Redwood	1000	
900 lb. *c* Port Orford Cedar	900	
900 lb. *c* Dense Shortleaf Southern Pine	900	
800 lb. *c* Western Red Cedar	800	

The detailed reasoning basic to these grades will be found by a study of a report of the U. S. Forest Products Laboratory, U. S. Department of Agriculture *Miscellaneous Publication No. 185*, entitled "Guide to the Grading of Structural Timbers and the Determination of Working Stresses," February, 1934. Reference should also be made to the "Working Stresses" appearing in the Appendix to the Standard Specifications for Structural Wood Joist and Plank, Beams and Stringers, and Posts and Timbers (A.S.T.M. Designation: D 245 - 33) of the American Society for Testing Materials.[1]

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[1] 1933 Book of A.S.T.M. Standards, Part II, p. 384.

TENTATIVE SPECIFICATIONS
FOR
ZINC CHLORIDE[1]

A.S.T.M. Designation: D 432 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1936.

Scope

1. These specifications cover zinc chloride, either from commercial concentrated solutions of zinc chloride, or fused or granulated zinc chloride for use in the preservative treatment of timber.

Properties

2. (*a*) *Iron Content.*—The zinc chloride shall be acid-free and shall not contain more than 0.1 per cent of iron.

(*b*) *Chloride of Zinc Content.*—The material shall conform to the following minimum requirements as to percentage content of chloride of zinc:

	CHLORIDE OF ZINC, MIN., PER CENT
Concentrated zinc chloride solution	50
Fused or solid zinc chloride	94

Methods of Chemical Analysis

3. The material shall be analyzed in accordance with the Standard Methods of Chemical Analysis of Zinc Chloride (A.S.T.M. Designation: D 199) of the American Society for Testing Materials.[2]

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-7 on Timber.

These specifications are identical in substance with the American Wood-Preservers' Association Standard Specification for Zinc Chloride (No. 17a).

[2] 1936 Book of A.S.T.M. Standards, Part II, p. 560.

AMERICAN TENTATIVE STANDARD
A.S.A. No.: Z11 37-1936

TENTATIVE METHOD OF TEST
FOR
KNOCK CHARACTERISTICS OF MOTOR FUELS[1]

A.S.T.M. Designation: D 357 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1933; REVISED, 1934, 1936.

This method has been approved as
AMERICAN TENTATIVE STANDARD
by the American Standards Association

Scope

1. This method is intended for determining the knock characteristics, in terms of an arbitrary scale of octane numbers, of gasolines and equivalent fuels for use in spark-ignition engines, other than engines for aircraft.

A.S.T.M. Octane Number

2. The A.S.T.M. octane number of a motor fuel is the whole number nearest to the octane number (Note 1) of that mixture of *iso*octane with normal heptane which the motor fuel matches in knock characteristics when compared by the procedure specified herein.

NOTE 1.—Octane number is defined by and is numerically equal to the percentage by volume of *iso*octane (2,2,4-trimethylpentane) in a mixture of *iso*octane and normal heptane, used as a primary standard for measurement of knock characteristics. Thus, by definition, normal heptane has an octane number of zero and *iso*octane of 100.

APPARATUS

Apparatus

3. The knock-testing unit described in this section shall be used without modification. The engine shall be known as the "C.F.R. Engine" and shall be marked[2] by plate or other approved

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[1] This method heretofore known as the C.F.R. Motor Method is based on the apparatus and procedure developed by the Cooperative Fuel Research Committee, composed of representatives of the American Petroleum Institute, National Automobile Chamber of Commerce, Society of Automotive Engineers and U. S. Bureau of Standards, who have been studying this problem since 1928.

Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee D-2 on Petroleum Products and Lubricants.

[2] At present the sole authorized manufacturer of the C.F.R. Engine is the Waukesha Motor Co., Waukesha, Wis. Other manufacturers may be approved in the future, but testing laboratories should not purchase engines except from Waukesha Motor Co. without ascertaining whether such engines have been approved. Inquiries in this connection should be directed to Mr. R. P. Anderson, secretary of Committee D-2 on Petroleum Products and Lubricants, 50 West 50th St., New York City.

means with a combination of the respective emblems of the American Society for Testing Materials and the Cooperative Fuel Research Committee, thus:

The apparatus shall consist of a continuously-variable-compression motor together with suitable loading and accessory equipment as follows:

(*a*) *Engine.*—Continuously-variable-compression, one-cylinder, with dimensions as follows:

Bore, in.	3.25
Stroke, in.	4.50
Displacement, cu. in.	37.4
Valve diameter, in. clear	1.1875
Connecting-rod bearing:	
diameter, in.	2.25
length, in.	1.625
Front main bearing:	
diameter, in.	2.25
length, in.	2.00
Rear main bearing:	
diameter, in.	2.25
length, in.	4.25
Piston pin, floating, diameter, in.	1.25
Connecting rod, center to center, in.	10.00
Timing gear face, in.	1.00
Piston rings, number	5
Exhaust pipe, diameter, in.	1.25
Spark plug, size, mm	18.00
Weight of engine, lb. (approximate)	475
Weight of complete unit, lb. (approximate)	1375

(*b*) *Crankshaft.*—Fully machined, heat-treated, and counterbalanced.

(*c*) *Crankcase.*—Cast iron, with rigid end walls.

(*d*) *Connecting Rod.*—Rifle-drilled, S.A.E. No. 1045 steel, heat-treated, bearing alloy cast directly into big end.

(*e*) *Main Bearings.*—Renewable sleeve bushings, babbitt-lined.

(*f*) *Valves.*—Silcrome. Inlet valve with specially designed shroud.

(*g*) *Push Rods.*—Mushroom type with lock-nut adjustment.

(*h*) *Cylinders.*—Cast of iron alloy, bored and honed, Brinell hardness, 200 to 210.

(*i*) *Cylinder Head.*—Integral with cylinder.

(*j*) *Cooling System.*—Evaporatively cooled.

(*k*) *Lubrication.*—Pressure feed to main connecting-rod, piston-pin, and camshaft bearings, and to idler gear stud and gears.

(*l*) *Oil Heater and Thermometer.*—Electric heater in base to bring oil to operating temperature quickly, and a thermometer on the instrument panel to indicate when equilibrium temperature has been reached.

(*m*) *Ignition.*—May be either a battery system or a magneto. A neon-tube spark indicator is built into the engine. Spark advance is automatically adjusted as the compression ratio is changed.

(*n*) *Carburetor.*[1]—A special C.F.R. carburetor is furnished with the engine, and can be obtained with either two or three float bowls. The carburetor has a fixed fuel jet, and each float bowl is individually adjustable for level with respect to the jet for varying mixture ratio. Fuel containers are furnished with the carburetor.

(*o*) *Mixture Heater.*—As supplied by manufacturer, consisting of (*1*) a manifold, (*2*) an electric immersion heater and rheostat for controlling mixture temperature and (*3*) a special mercury-stem thermometer, 100 to 400° F. (38 to 204° C.), so mounted that the bulb is centered in the mixture stream to indicate the mixture temperature.

(*p*) *Instruments.*—Knock intensity is measured by a bouncing pin, in conjunction with a knockmeter. (The knockmeter is a damped hot-wire ammeter which indicates the effective current in the circuit, thus permitting instantaneous readings.) Current is supplied from a small direct-current generator, belt-driven from the power-absorbing unit.

(*q*) *Power-Absorbing Unit.*—The engine is connected by V-type belts to an electric generator. This preferably should be an induction motor with synchronous characteristics but may be any electric generator capable of maintaining proper operating conditions. In most cases the electric generator will act as a starting motor to crank the engine, but if a direct-current generator is used and no outside source of current is available, the engine may have to be cranked by hand.

(*r*) *Complete Unit.*—The complete unit may be obtained with the engine, generator, and panel board mounted on a cast-iron base plate. All necessary instruments and accessories are furnished with the unit.

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[1] The use of knock-testing apparatus equipped with the carburetor described in the 1933 edition of the method (*Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 746 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 540) is permissible.

Foundation

4. The foundation shall be of concrete and at least 18 in. high. If possible, it should be prepared by pouring on a concrete floor. Proper dimensions will be furnished with the engine. For convenience in operation, the foundation should be placed at least 2 ft. from any wall. Should the floor of the building on which the engine is to be installed be other than portland-cement concrete, the floor should be cut away so that the engine foundation will rest directly on the ground. In such case the bearing area of the foundation will depend upon the condition of the underlying soil and should be such as to give ample footing.

Reference Fuels

5. *Primary Reference Fuels.*—The primary[1] reference fuels shall be *iso*octane (2,2,4-trimethylpentane), and normal heptane (Note 1). Both shall be certified for suitability as primary reference fuels by the National Bureau of Standards (Note 2).

NOTE 1. *Secondary Reference Fuels.*—Mixtures of normal heptane and *iso*octane required for referee testing are expensive. For this reason secondary reference fuels may be used for routine determinations.[2] Such secondary reference fuels may be straight-run or other stable gasolines suitable for the purpose. One of the reference fuels should be of low knock rating and the other of high knock rating, or if a sufficiently high-knock-rating fuel is not available, a mixture of the higher-knock-rating fuel plus a knock suppressor may be used. These secondary reference fuels shall be calibrated on the octane-number scale against normal heptane and *iso*octane sufficiently often to insure accuracy of calibration; and for every case, whether a fuel is rated by secondary reference fuels or by means of normal heptane and *iso*octane, the result shall be recorded as an octane number.

NOTE 2.—For the present this certification consists of tests made by the Bureau of Standards on each batch of normal heptane or *iso*octane prepared respectively by the two companies mentioned,[1] with certificates issued to these companies authorizing them to guarantee to the purchaser that the material shipped is a part of a batch so tested and to quote the results of the Bureau of Standards' tests.

Standard Operating Conditions

6. The engine shall be run under the following standard conditions:

(*a*) *Engine Speed.*—900 r.p.m. ± 3 r.p.m.

(*b*) *Jacket Temperature.*—Constant within ± 1° F. (0.6° C.) and at a temperature between the limits of 205 and 215° F. (96 and 102° C.).

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[1] At present, *iso*octane may be obtained from Rohm & Haas Co., 222 W. Washington Square, Philadelphia, Pa., and normal heptane from the California Chemical Co., 220 Bush Street, San Francisco, Calif.

[2] Such secondary reference fuels are commercially available through the Standard Oil Company of New Jersey with calibration curves as determined by the supplier in accordance with this method, giving octane numbers for these fuels blended with each other and with benzene and tetraethyl lead. They may be ordered from the Standard Oil Development Co., 26 Broadway, New York City.

(*c*) *Cooling Liquid.*—Distilled water, rain water, or ethylene-glycol solution when necessary at high altitude.

(*d*) *Crankcase Lubricating Oil.*—S. A. E. 30.

NOTE.—The viscosity range of crankcase lubricating oil, S.A.E. 30, is from 185 to 255 seconds when determined on the Saybolt Universal viscosimeter at 130° F. (54.4° C.), in accordance with the Standard Method of Test for Viscosity by Means of the Saybolt Viscosimeter (A.S.T.M. Designation: D 88) of the American Society for Testing Materials.[1]

(*e*) *Oil Pressure.*—25 to 30 lb. per sq. in. under operating conditions.

(*f*) *Oil Temperature.*—The electric oil heater shall be used only to raise the oil temperature rapidly to the equilibrium operating temperature, normal operation maintaining the equilibrium thereafter. By "equilibrium" is meant that steady temperature attained by the oil upon continuous operation of the engine without the use of the heater.

(*g*) *Valve Clearances.*—Intake 0.008 in., cold; exhaust 0.010 in., cold.

(*h*) *Spark Advance.*—Automatically controlled:

26.0 deg. at 5:1 compression ratio (basic setting);
22.0 deg. at 6:1 compression ratio;
19.0 deg. at 7:1 compression ratio.

(*i*) *Breaker-Point Clearance.*—Battery system 0.015 in.; magneto 0.020 in.

(*j*) *Spark Plug.*—Shall conform to the standard metric plug having the tolerances and thermal characteristics equal to the No. 8 spark plug furnished by the Champion Spark Plug Co., Toledo, Ohio. Gap setting, 0.025 in.

(*k*) *Throttle Opening.*—All tests shall be conducted with the throttle opening at the point of maximum volumetric efficiency, approximately 90 on the throttle scale.

(*l*) *Carburetor Adjustment.*—For maximum knock.

(*m*) *Exhaust Pipe.*—A separate exhaust pipe should be used for each engine. This pipe should be made from 1¼-in. pipe having a maximum of two ells with a total length not to exceed 20 ft. The use of a short straight-through muffler of 1¼-in. diameter passage for prevention of noise is permissible.

(*n*) *Mixture Temperature.*—The mixture temperature shall be maintained at 300° F. ±2° F. (149° C. ±1.1° C.) as indicated by the mercury stem thermometer.

(*o*) *Bouncing Pin Assembly.*—The gap setting shall be 0.003 in. to 0.005 in.

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[1] 1936 Book of A.S.T.M. Standards, Part II, p 982.

NOTE.—The following instructions for setting of the bouncing-pin contacts should be used: With the daily inspection, observe the contact points and electrical connections to see that the points are smooth and that all the connections are tight. The gap setting should be checked (0.003-in. to 0.005-in.). The flat spring of the lower contact should touch the insulated pin with slight pressure. Too much pressure will reduce its sensitivity. To adjust the pressure accurately, set the points with 0.003-in. to 0.005-in. clearance. Then remove the diaphragm and bouncing pin. Bend the lower spring until there is from $\frac{3}{64}$-in. to $\frac{1}{16}$-in. gap between the points. Remove the upper stop-adjusting screw and bend the upper spring until there is $\frac{5}{32}$-in. gap between the points. Check the tension on the small plunger spring in upper stop-adjusting screw and see that it has from 1- to $1\frac{1}{4}$-lb. initial tension. This can be measured by pressing it against any convenient platform scale. The pin should then be re-assembled and the adjusting screw set to give 0.003-in. to 0.005-in. gap between the points. The final adjustment is made by setting the clearance so that a knockmeter reading between 50 and 60 is obtained when operating the engine at the proper knock intensity.

PROCEDURE

Starting and Stopping the Engine

7. While the engine is being turned over by electric motor the ignition shall be turned on and the carburetor set so as to draw fuel from one float bowl. To stop the engine the fuel and the ignition switch shall be turned off and then the motor shall be stopped by means of the push-button switch. To avoid corrosion of valves and seats between operating periods the engine should be turned over by hand until both valves are closed.

Preliminary Adjustment of Compression Ratio

8. Using a mixture of 65 parts of *iso*octane and 35 parts of normal heptane, the compression ratio for first audible knock shall be obtained by increasing the compression ratio, by increments of two turns of the crank, from a point where there is no knock to the compression ratio at which audible knock is first detected. The proper knock intensity for use in making knock ratings shall be the knock intensity obtained with the mixture of 65 parts of *iso*octane and 35 parts of normal heptane when the compression ratio is increased one unit over that compression ratio giving first audible knock. Then the numerical indication of knock intensity obtained from the knockmeter shall be recorded. This procedure is necessary for the first adjustment only.

NOTE.—This knock intensity should be equivalent to the intensity obtained with a mixture of 65 per cent of *iso*octane and 35 per cent of normal heptane at a compression ratio of 5.3 ± 0.05 to 1 when testing at a barometric pressure of 760 mm.

For subsequent tests on fuel samples the compression ratio shall be set to duplicate the knock intensity as recorded above, provided no change has been made in the bouncing-pin adjustment in the meantime. In no case shall the knock intensity be such that the engine does not cease firing when ignition is interrupted.

Outline of Procedure

9. The octane number of a fuel shall be ascertained by comparing the knock intensity for the fuel with those for various blends of the reference fuels until two blends differing in knock rating by not more than two octane numbers are found, one of which gives a higher knock intensity than the fuel and the other a lower knock intensity. The knock intensity shall be measured by a bouncing-pin indicator in conjunction with a knockmeter.

Before the test sample and the blends of the reference fuels can be compared, the compression ratio must be set to give the proper knock intensity and the carburetor adjusted to give the maximum knock for each fuel.

Adjustment of Carburetor for Test Fuel

10. Using the fuel whose knock rating is to be determined, the carburetor shall be adjusted as follows: After one float bowl of the carburetor has been filled with the fuel of which the octane number is to be determined, adjustment shall be made to obtain maximum knock by raising and lowering the level of the float bowl and noting whether the knockmeter reading increases or decreases. The float bowl shall then be moved in the direction in which the knock increases until the knock passes through a maximum. This point shall be checked three times and the float bowl set at the position of maximum knock. The knockmeter needle shall be allowed to reach equilibrium after each adjustment of the float-bowl level.

Final Adjustment of Compression Ratio

11. Finally, adjust the compression ratio to give the same reading on the knockmeter when using the fuel under test as was obtained in the first adjustment under Section 8.

12. A trial blend[1] of the low-octane-number reference fuel and the high-octane-number reference fuel, based on the expected knock rating of the fuel sample under test, shall be placed in another carburetor float bowl and the engine run on this trial blend. The level of this float bowl shall then be adjusted to the maximum knock position in a manner similar to that described in Section 10.

Octane Number Determination

13. With the carburetor set for the air-fuel ratio of maximum knock, alternate series of readings of knock intensity shall be taken on the fuel under test and on a reference fuel blend. The knockmeter

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[1] Extreme care is required to insure thorough mixing of ingredients.

needle shall be allowed to reach equilibrium before the final reading is recorded.

At least 3 alternate series of readings shall be taken on each fuel. After changing from one fuel to another, at least 1 minute shall be allowed for the engine to reach equilibrium. With some fuels an appreciably longer time interval may be required. If the average knock intensity of the fuel sample is higher than the average of the reference fuel blend, the test shall be repeated with a blend containing a decreased proportion of the high-octane-number reference fuel.[1] The test shall be continued in this manner until the knock intensity for the fuel sample is definitely higher than one blend and lower than another blend of the reference fuels. The difference between these two final reference fuel blends shall be not more than two octane numbers.

CALCULATION

Calculation

14. The knock rating of the fuel sample shall be obtained by interpolation from the figures so recorded and the nearest whole number shall be reported as A.S.T.M. octane number.

Check of Test Conditions

15. Test conditions shall not be regarded as standard unless a blend by volume of 65 per cent *iso*octane and 35 per cent normal heptane is matched under the specified procedure by a blend by volume of 68 ±1 per cent one-degree benzene with 32 ±1 per cent normal heptane. At atmospheric pressure of 760 mm. a compression ratio of approximately 5.3:1 is correct for this determination. Substantial variations in atmospheric pressure will change the compression ratio required.

NOTE 1.—For routine checking purposes, one-degree benzene and secondary reference fuels may be used.

NOTE 2.—"One-degree" benzene[2] is a commercial product conforming to the following requirements:

(*a*) Boiling range not greater than 1° C., embracing the boiling point of chemically pure benzene.

(*b*) Specific gravity of from 0.882 to 0.886, when determined in accordance with the Standard Method of Test for Gravity of Petroleum and Petroleum Products by Means of the Hydrometer (A.S.T.M. Designation: D 287) of the American Society for Testing Materials.[3]

(*c*) Free from hydrogen sulfide, carbon disulfide and thiophene.

(*d*) Free from turbidity, with color not darker than a solution of 3 mg. of potassium dichromate in 1 liter of water when compared in 50-ml. Nessler tubes.

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[1] When changing fuels in the containers, the fuel in the container shall be drained completely by means of the drain-cock provided. A small portion of the new fuel shall be allowed to flow through the line before closing the drain-cock.

[2] "One-degree" benzene may be procured from The Barrett Co., 40 Rector St., New York City

[3] 1936 Book of A.S.T.M. Standards, Part II, p. 918.

ACCURACY

Accuracy

16. Results obtained by this procedure with different C. F. R. engines and in different laboratories should differ by not more than two octane numbers.

While the accuracy of this method is as above stated, its sensitivity may permit detection of differences as small as 0.2 octane number when alternate readings of knock intensity are taken on the two fuels as directed in Section 13.

MAINTENANCE

Maintenance

17. It is recommended that a systematic inspection of the testing apparatus be carried out with the utmost care after each 50 hours of operation. The following points should be emphasized:

(*a*) *Bouncing Pin.*—Lack of sensitivity, fluctuating knockmeter reading, or irregular gas evolution may indicate diaphragm trouble. The diaphragm retaining nut should be tightened and any carbon accumulation removed. If this does not correct the condition, the diaphragm may have deteriorated and may need to be replaced.

(*b*) *Breaker Points.*—If necessary, pits should be removed and breaker-point clearance adjusted.

(*c*) *Spark Plugs.*—The porcelain should be carefully inspected for cracks, and defective plugs replaced. The spark gap shall be carefully checked and adjusted if necessary. When plugs are re-used any carbon deposit on the metal body of the plug or on the electrodes shall be removed mechanically before making gap adjustments.

(*d*) *Fuel System.*—Any foreign matter in the fuel containers, float bowls, lines, or carburetor shall be removed. Blowing with air and then flushing the fuel system with gasoline or benzol is a convenient method.

(*e*) *Cooling System.*—Any leaks revealed by inspection shall be repaired.

(*f*) *Combustion Chamber.*—Carbon deposits shall be removed by scraping.

(*g*) *Compression Pressure.*—The cause of any abnormal change between inspections shall be investigated and corrected.

(*h*) *Valves.*—Valves shall be removed and reground unless there is a continuous polished line of contact on both the valve and the valve seat. After reassembling, the valve-tappet clearances shall be carefully adjusted.

(*i*) *Piston Rings.*—Carbon shall be removed from rings and grooves.

(*j*) The intake manifold and heater blades shall be inspected and cleaned if necessary.

AMERICAN TENTATIVE STANDARD
A.S.A. NO.: Z11.28-1936

TENTATIVE DEFINITIONS OF TERMS RELATING TO PETROLEUM[1]

A.S.T.M. Designation: D 288 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1928; Revised, 1931, 1935, 1936.[2]

These definitions have been approved as
AMERICAN TENTATIVE STANDARD
by the American Standards Association

Benzine.—This term is archaic and misleading and should not be used.

Crude Petroleum.—A naturally occurring mixture, consisting predominantly of hydrocarbons, and/or of sulfur, nitrogen and/or oxygen derivatives of hydrocarbons, which is removed from the earth in liquid state or is capable of being so removed.

Note.—Crude petroleum is commonly accompanied by varying quantities of extraneous substances such as water, inorganic matter and gas. The removal of such extraneous substances alone does not change the status of the mixture as crude petroleum. If such removal appreciably affects the composition of the oil mixture, then the resulting product is no longer crude petroleum

Crude Shale Oil.—The oil obtained as a distillate by the destructive distillation of oil-shale.

End Point.—The highest temperature reading observed on the distillation thermometer during the distillation procedure conducted in accordance with the Standard Method of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (A.S.T.M. Designation: D 86) and the Standard Method of Test for Distillation of Natural Gasoline (A.S.T.M. Designation: D 216) of the American Society for Testing Materials.

Engine Distillate.—A refined or unrefined petroleum distillate similar to naphtha, but often of higher distillation range.

Fuel Oil.—Any liquid or liquefiable petroleum product burned for the generation of heat in a furnace or firebox, or for the generation of power in an engine, exclusive of oils with a flash point below 100° F., Tag closed tester, and oils burned in cotton or wool-wick burners. Fuel oils in common use fall into one of four classes: (1) residual fuel oils, which are topped crude petroleums or viscous residuums obtained in refinery operations; (2) distillate fuel oils, which are distillates derived directly or indirectly from crude petroleum; (3) crude petroleums and weathered crude petroleums of relatively low commercial value; (4) blended fuels, which are mixtures of two or more of the three preceding classes.

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[1] Under the standardization procedure of the Society, these definitions are under the jurisdiction of the A.S.T.M. Committee D-2 on Petroleum Products and Lubricants.

[2] Latest revision accepted by Committee E-10 on Standards, August 26, 1936.

Gas Oil.—A liquid petroleum distillate having a viscosity intermediate between that of kerosine and lubricating oil.

NOTE.—It should be understood that oils, other than gas oil as defined above, may be and are used in the manufacture of gas.

Gasoline.—A refined petroleum naphtha which by its composition is suitable for use as a carburant in internal combustion engines.

Kerosine.—A refined petroleum distillate having a flash point not below 73° F. (23° C.), as determined by the Abel Tester (which is approximately equivalent to 73° F. (23° C.) as determined by the Tag Closed Tester, A.S.T.M. Standard Method D 56) and suitable for use as an illuminant when burned in a wick lamp.

NOTE.—In the United States of America local ordinances or insurance regulations require flash points higher than 73° F. (23° C.), Tag Closed Tester.

Oil-Shale.—A compact rock of sedimentary origin, with an ash content of more than 33 per cent and containing organic matter that yields oil when destructively distilled but not appreciably when extracted with the ordinary solvents for petroleum.

Petroleum Grease.—A semisolid or solid combination of a petroleum product and a soap or a mixture of soaps, with or without fillers, suitable for certain types of lubrication.

Petroleum Naphtha.—A generic term applied to refined, partly refined or unrefined petroleum products and liquid products of natural gas, not less than 10 per cent of which distills below 347° F. (175° C.) and not less than 95 per cent of which distills below 464° F. (240° C.), when subjected to distillation in accordance with the Standard Method of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (A.S.T.M. Designation: D 86) of the American Society for Testing Materials.

NOTE.—The "naphthas" used for specific purposes such as cleaning, manufacture of rubber, manufacture of paints and varnishes, etc., are made to conform to specifications which may require products of considerably greater volatility than that set by the limits of this generic definition.

Petroleum Spirits (White Spirits).—A refined petroleum distillate with a minimum flash point of 70° F. (21° C.) determined by the Tag Closed Tester in accordance with the Standard Method of Test for Flash Point by Means of the Tag Closed Tester (A.S.T.M. Designation: D 56) of the American Society for Testing Materials or by the Abel Tester, with volatility and other properties making it suitable as a thinner and solvent in paints, varnishes and similar products.

NOTE.—The term "turpentine substitute" as applied to petroleum spirits is to be condemned as false and misleading. The term "mineral spirits" which is frequently used in the paint and varnish industry is a misnomer as it includes within its scope not only petroleum products, but other hydrocarbon mixtures, such as coal-tar distillates. In Great Britain the term "petroleum spirits" is applied to a very light hydrocarbon mixture having a flash point below 32° F. (0° C.).

Pitch.—This term shall not be applied to petroleum products.

Tar.—This term shall not be applied to petroleum products.

Topped Crude Petroleum.—A residual product remaining after the removal, by distillation, or other artificial means, of an appreciable quantity of the more volatile components of crude petroleum.

Tops.—The unrefined distillate obtained in topping a crude petroleum.

Weathered Crude Petroleum.—The product resulting from crude petroleum through loss, due to natural causes, during storage and handling, of an appreciable quantity of the more volatile components.

TENTATIVE SPECIFICATIONS

FOR

EMULSIFIED ASPHALT[1]

(FOR COARSE AGGREGATE PLANT MIXES)

A.S.T.M. Designation: D 397 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934; REVISED, 1936.

Properties and Tests

1. (*a*) Emulsified asphalt shall be homogeneous. It shall show no separation of asphalt after thorough mixing, within 30 days after delivery, provided separation has not been caused by freezing.

(*b*) Emulsified asphalt for coarse aggregate plant mixes shall conform to the following requirements:

Viscosity, Saybolt Furol, 60 ml. at 25 C. (77 F.)	not less than 100 sec.
Residue by distillation	not less than 60 per cent, and not more than 65 per cent
Settlement, 5 days	not more than 5
Demulsibility,[a] 50 ml. of 0.1 *N* $CaCl_2$	not more than 30 per cent
Sieve test	not more than 0.10 per cent
Miscibility with water	no appreciable coagulation in 2 hr.
Coating test	it shall not show appreciable separation when mixed with washed, dry, clean stone for 3 min. and shall coat the stone thoroughly.

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[a] The demulsibility test shall be made within 30 days from date of shipment.

(*c*) *Residue.*—The residue obtained from distillation shall conform to the following requirements:

Penetration at 25 C. (77 F.), 100 g., 5 sec		100 to 200
Soluble in carbon disulfide	petroleum asphalts	not less than 97.5 per cent
	native asphalts	not less than 95 per cent
Ash		not more than 2 per cent
Ductility at 25 C. (77 F.)		not less than 40 cm.
Specific gravity at 25 C. (77 F.)		not less than 1.00

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-4 on Road and Paving Materials.

Basis of Purchase

2. Prior to the award of the order or contract, a sample may be tested by the purchaser and if it fails to comply with the specification requirements, the bid accompanying the sample shall be rejected. The sample shall be taken under the supervision of the purchaser, from factory storage containing not less than 20,000 gal. of the emulsified asphalt and shall be kept in a clean air-tight sealed container at a temperature of not less than 4 C. (40 F.) until tested.

Sampling

3. At least one sample of not less than 1 gal. shall be taken from each lot or shipment of the emulsified asphalt after arrival at its destination. The samples shall be stored in clean air-tight containers at a temperature of not less than 4 C. (40 F.) until tested.

Methods of Testing

4. The properties enumerated in these specifications shall be determined in accordance with the Tentative Methods of Testing Emulsified Asphalts (A.S.T.M. Designation: D 244 - 36 T) of the American Society for Testing Materials.[1]

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[1] See p. 880.

TENTATIVE SPECIFICATIONS
FOR
EMULSIFIED ASPHALT[1]
(FOR RETREAD AND COARSE AGGREGATE MIXES)

A.S.T.M. Designation: D 398 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934; REVISED, 1936.

Properties and Tests

1. (*a*) Emulsified asphalt shall be homogeneous. It shall show no separation of asphalt after thorough mixing, within 30 days after delivery, provided separation has not been caused by freezing.

(*b*) Emulsified asphalt for retread and coarse aggregate mixes shall conform to the following requirements:

Viscosity, Saybolt Furol, 60 ml. at 25 C. (77 F.)	not less than 20 sec., and not more than 100 sec.
Residue by distillation	not less than 55 per cent, and not more than 60 per cent
Settlement, 5 days	not more than 5
Demulsibility,[a] 50 ml. of 0.1 *N* $CaCl_2$	not more than 30 per cent
Sieve test	not more than 0.10 per cent
Miscibility with water	no appreciable coagulation in 2 hr.
Coating test	it shall not show appreciable separation when mixed with washed, dry, clean stone for 3 min. and shall coat the stone thoroughly.

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[a] The demulsibility test shall be made within 30 days from date of shipment.

(*c*) ***Residue.***—The residue obtained from distillation shall conform to the following requirements:

Penetration at 25 C. (77 F.), 100 g., 5 sec		100 to 200
Soluble in carbon disulfide	petroleum asphalts	not less than 97.5 per cent
	native asphalts	not less than 95 per cent
Ash		not more than 2 per cent
Ductility at 25 C. (77 F.)		not less than 40 cm
Specific gravity at 25 C. (77 F.)		not less than 1.00

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-4 on Road and Paving Materials.

Basis of Purchase

2. Prior to the award of the order or contract, a sample may be tested by the purchaser and if it fails to comply with the specification requirements, the bid accompanying the sample shall be rejected. The sample shall be taken under the supervision of the purchaser, from factory storage containing not less than 20,000 gal. of the emulsified asphalt and shall be kept in a clean air-tight sealed container at a temperature of not less than 4 C. (40 F.) until tested.

Sampling

3. At least one sample of not less than 1 gal. shall be taken from each lot or shipment of the emulsified asphalt after arrival at its destination. The samples shall be stored in clean air-tight containers at a temperature of not less than 4 C. (40 F.) until tested.

Methods of Testing

4. The properties enumerated in these specifications shall be determined in accordance with the Tentative Methods of Testing Emulsified Asphalts (A.S.T.M. Designation: D 244 - 36 T) of the American Society for Testing Materials.[1]

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[1] See p. 880.

TENTATIVE SPECIFICATIONS
FOR
EMULSIFIED ASPHALT[1]
(HEAVY PREMIX—SUMMER GRADE)

A.S.T.M. Designation: D 399 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934; REVISED, 1936.

Properties and Tests

1. (*a*) Emulsified asphalt shall be homogeneous. It shall show no separation of asphalt after thorough mixing, within 30 days after delivery, provided separation has not been caused by freezing.

(*b*) Emulsified asphalt (heavy premix - summer grade) shall conform to the following requirements:

Residue by distillation	not less than 65 per cent
Sieve test	not more than 0.10 per cent
Miscibility with water	no appreciable coagulation in 2 hr.
Coating test	it shall not show appreciable separation when mixed with washed, dry, clean stone for 3 min. and shall coat the stone thoroughly.

(*c*) *Residue.*—The residue obtained from distillation shall conform to the following requirements:

Penetration at 25 C. (77 F.), 100 g., 5 sec		100 to 200
Soluble in carbon disulfide	petroleum asphalts	not less than 97.5 per cent
	native asphalts	not less than 95 per cent
Ash		not more than 2 per cent
Ductility at 25 C. (77 F.)		not less than 40 cm.
Specific gravity at 25 C. (77 F.)		not less than 1.00

Basis of Purchase

2. Prior to the award of the order or contract, a sample may be tested by the purchaser and if it fails to comply with the specification requirements, the bid accompanying the sample shall be rejected. The sample shall be taken under the supervision of the purchaser, from factory storage containing not less than 20,000 gal. of the emulsified asphalt and shall be kept in a clean air-tight sealed container at a temperature of not less than 4 C. (40 F.) until tested.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-4 on Road and Paving Materials.

Sampling

3. At least one sample of not less than 1 gal. shall be taken from each lot or shipment of the emulsified asphalt after arrival at its destination. The samples shall be stored in clean air-tight containers at a temperature of not less than 4 C. (40 F.) until tested.

Methods of Testing

4. The properties enumerated in these specifications shall be determined in accordance with the Tentative Methods of Testing Emulsified Asphalts (A.S.T.M. Designation: D 244 - 36 T) of the American Society for Testing Materials.[1]

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[1] See p. 880.

TENTATIVE SPECIFICATIONS
FOR
EMULSIFIED ASPHALT[1]
((QUICK-SETTING) FOR PENETRATION AND SURFACE TREATMENT)

A.S.T.M. Designation: D 401 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934; REVISED, 1936.

Properties and Tests

1. (*a*) Emulsified asphalt shall be homogeneous. It shall show no separation of asphalt after thorough mixing, within 30 days after delivery, provided separation has not been caused by freezing.

(*b*) Emulsified asphalt (quick-setting) for penetration and surface treatment shall conform to the following requirements:

Viscosity, Saybolt Furol, 60 ml. at 25 C. (77 F.)	not less than 20 sec., and not more than 100 sec.
Residue by distillation	not less than 55 per cent, and not more than 60 per cent
Settlement, 5 days	not more than 3
Demulsibility,[a] 35 ml. of 0.02 N $CaCl_2$	not less than 60 per cent
Sieve test	not more than 0.10 per cent

(*c*) *Residue.*—The residue obtained from distillation shall conform to the following requirements:

Penetration at 25 C. (77 F.), 100 g., 5 sec		100 to 200
Soluble in carbon disulfide	petroleum asphalts	not less than 97.5 per cent
	native asphalts	not less than 95 per cent
Ash		not more than 2 per cent
Ductility at 25 C. (77 F.)		not less than 40 cm.
Specific gravity at 25 C. (77 F.)		not less than 1.00

[a] The demulsibility test shall be made within 30 days from date of shipment.

Basis of Purchase

2. Prior to the award of the order or contract, a sample may be tested by the purchaser and if it fails to comply with the specification requirements, the bid accompanying the sample shall be rejected. The sample shall be taken under the supervision of the purchaser, from factory storage containing not less than 20,000 gal. of the emulsi-

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-4 on Road and Paving Materials.

fied asphalt and shall be kept in a clean air-tight sealed glass or black iron container at a temperature of not less than 4 C. (40 F.) until tested.

Sampling

3. At least one sample of not less than 1 gal. shall be taken from each lot or shipment of the emulsified asphalt after arrival at its destination. The samples shall be stored in clean air-tight glass or black iron containers at a temperature of not less than 4 C. (40 F.) until tested.

Methods of Testing

4. The properties enumerated in these specifications shall be determined in accordance with the Tentative Methods of Testing Emulsified Asphalts (A.S.T.M. Designation: D 244 - 36 T) of the American Society for Testing Materials.[1]

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[1] See p. 880.

TENTATIVE SPECIFICATIONS
FOR
HIGH-CARBON TAR CEMENT[1]

A.S.T.M. Designation: D 110 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED AS TENTATIVE, 1921; ADOPTED IN AMENDED FORM, 1930;
REVERTED TO TENTATIVE, 1936.

Scope. 1. These specifications cover material suitable for use in the construction of tar macadam and tar concrete pavements.

Properties. 2. The tar cement shall conform to the following requirements:

(*a*) Water .... 0.00 per cent

(*b*) Softening point[2] (Ring-and-Ball Method) .... 30 to 40° C. (86 to 104° F.)[3]

(*c*) Distillation test:

Total Distillate, by weight, 0 to 170° C. (32 to 338° F.)	not more than 1.00	per cent
Total Distillate, by weight, 0 to 270° C. (32 to 518° F.)	not more than 10.00	"
Total Distillate, by weight, 0 to 300° C. (32 to 572° F.)	not more than 20.00	"
Residue, by weight	not less than 80.00	"

(*d*) Specific gravity at 38° C. (100.4° F.) of total distillate to 300° C. (572° F.) .... not less than 1.02

(*e*) Softening point (Ring-and-Ball Method) of residue from distillation test .... not more than 65° C. (149° F.)

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-4 on Road and Paving Materials.

[2] If desired, a float test may be substituted for the softening point test, in which case the requirements shall be as follows: Float Test at 50° C. (122° F.), 100 to 220 sec.

[3] The specification range for softening point, within the above limits, should be 5° C. for any given locality, for example, 30 to 35° C. for cold climates, equivalent to a float test at 50° C. of 100 to 160 sec.; 35 to 40° C. for warm climates, equivalent to a float test at 50° C. of 160 to 220 sec.

(*f*) Total Bitumen (Soluble in Carbon Disulfide)[1]............. ....78 to 95 per cent

Methods of Testing.

3. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Percentage of Water:* Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (A.S.T.M. Designation: D 95);[2]

(*b*) *Softening Point:* Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (A.S.T.M. Designation: D 36);[3]

(*c*) *Distillation:* Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (A.S.T.M. Designation: D 20);[4]

(*d*) *Float Test:* Standard Method of Float Test for Bituminous Materials (A.S.T.M. Designation: D 139);[5]

(*e*) *Total Bitumen:* Standard Method of Test for the Determination of Bitumen (A.S.T.M. Designation: D 4).[6]

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[1] The specification range for total bitumen covers a wide variety of materials. If products from vertical retort or low-carbon coke-oven tars are desired, a range of 88 to 95 per cent should be specified. If high-carbon coke-oven or mixtures of coke-oven and gas-house tars are desired, a range of 78 to 88 per cent should be specified.

[2] 1936 Book of A.S.T.M. Standards, Part II, p. 997.

[3] *Ibid.*, p. 1098.

[4] *Ibid.*, p. 1053.

[5] *Ibid.*, p. 1061.

[6] *Ibid.*, p. 1041.

TENTATIVE SPECIFICATIONS
FOR
LOW-CARBON TAR CEMENT[1]

A.S.T.M. Designation: D 111 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued as Tentative, 1921; Adopted in Amended Form, 1930;
Reverted to Tentative, 1936.

Scope. 1. These specifications cover material suitable for use in the construction of tar macadam and tar concrete pavements.

Properties. 2. The tar cement shall conform to the following requirements:

(*a*) Water..................................0.00 per cent

(*b*) Softening point[2] (Ring-and-Ball Method)...30 to 40° C. (86 to 104° F.)[3]

(*c*) Distillation test:

Total Distillate, by weight, 0 to 170° C. (32 to 338° F.)	not more than	1.00	per cent
Total Distillate, by weight, 0 to 235° C. (32 to 455° F.)	not more than	2.00	"
Total Distillate, by weight, 0 to 270° C. (32 to 518° F.)	not more than	10.00	"
Total Distillate, by weight, 0 to 300° C. (32 to 572° F.)	not more than	20.00	"
Residue, by weight	not less than	80.00	"

(*d*) Softening point (Ring-and-Ball Method) of residue from distillation test.......................not more than 65° C. (149° F.)

(*e*) Total Bitumen (Soluble in Carbon Disulfide).....................................not less than 95 per cent

Methods of Testing. 3. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-4 on Road and Paving Materials.

[2] If desired, a float test may be substituted for the softening point test, in which case the requirements shall be as follows: Float Test at 50° C. (122° F.), 100 to 220 sec.

[3] The specification range for softening point, within the above limits, should be 5° C. for any given locality, for example, 30 to 35° C. for cold climates, equivalent to a float test at 50° C. of 100 to 160 sec.; 35 to 40° C. for warm climates, equivalent to a float test at 50° C. of 160 to 220 sec.

(*a*) *Percentage of Water:* Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (A.S.T.M. Designation: D 95);[1]

(*b*) *Softening Point:* Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (A.S.T.M. Designation: D 36);[2]

(*c*) *Distillation:* Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (A.S.T.M. Designation: D 20);[3]

(*d*) *Float Test:* Standard Method of Float Test for Bituminous Materials (A.S.T.M. Designation: D 139);[4]

(*e*) *Total Bitumen:* Standard Method of Test for the Determination of Bitumen (A.S.T.M. Designation: D 4).[5]

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 997.

[2] *Ibid.*, p. 1098.

[3] *Ibid.*, p. 1053.

[4] *Ibid.*, p. 1061.

[5] *Ibid.*, p. 1041.

TENTATIVE SPECIFICATIONS
FOR
HIGH-CARBON TAR FOR SURFACE TREATMENT, COLD APPLICATION[1]

A.S.T.M. Designation: D 104 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED AS TENTATIVE, 1921; ADOPTED IN AMENDED FORM, 1930;
REVERTED TO TENTATIVE, 1936.

Properties. 1. The tar shall conform to the following requirements:

(*a*) Water........................not more than 2.00 per cent

(*b*) Specific viscosity, Engler,[2] 50 cc. at 40° C. (104° F.)..8 to 35

(*c*) Distillation test on water-free material:

Total Distillate, by weight, 0 to 170° C. (32 to 338° F.)	not more than 7.00 per cent
Total Distillate, by weight, 0 to 235° C. (32 to 455° F.)	not more than 20.00 "
Total Distillate, by weight, 0 to 270° C. (32 to 518° F.)	not more than 30.00 "
Total Distillate, by weight, 0 to 300° C. (32 to 572° F.)	not more than 35.00 "
Residue, by weight	not less than 65.00 "

(*d*) Specific gravity at 25° C. (77° F.) of total distillate to 300° C. (572° F.)................................ not less than 1.00

(*e*) Softening point (Ring-and-Ball Method) of residue from distillation test.......................not more than 60° C. (140° F.)

(*f*) Total Bitumen (Soluble in Carbon Disulfide)..88 to 97 per cent

Methods of Testing. 2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials, except as specified in Paragraph (*b*):

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-4 on Road and Paving Materials.

[2] Within the viscosity limits designated a material should be chosen to meet the local conditions of temperature, road conditions and climate. It is recommended that materials be called for under the following range and headings: Light 8-13, Medium 13-18, Heavy 18-25, Extra Heavy 25-35.

(*a*) *Percentage of Water:* Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (A.S.T.M. Designation: D 95);[1]

(*b*) *Specific Viscosity:*[2] Method contained in *Bulletin No. 1216*, U. S. Department of Agriculture, the instrument being standardized by the U. S. Bureau of Standards. The results shall be reported as specific viscosity compared with water at 25° C. (77° F.).

(*c*) *Distillation:* Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (A.S.T.M. Designation: D 20);[3]

(*d*) *Softening Point:* Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (A.S.T.M. Designation: D 36);[4]

(*e*) *Total Bitumen:* Standard Method of Test for the Determination of Bitumen (A.S.T.M. Designation: D 4).[5]

---

[1] 1936 Book of A.S.T.M. Standards, Part II, p. 997.

[2] The **Engler test** has not been standardized by the American Society for Testing Materials. Committees of the Society have under consideration the Saybolt Furol apparatus, which may be adopted later.

[3] 1936 Book of A.S.T.M. Standards, Part II, p. 1053.

[4] *Ibid.*, p. 1098.

[5] *Ibid.*, p. 1041.

TENTATIVE SPECIFICATIONS
FOR
LOW-CARBON TAR FOR SURFACE TREATMENT, COLD APPLICATION[1]

A.S.T.M. Designation: D 105 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED AS TENTATIVE, 1921; ADOPTED IN AMENDED FORM, 1930;
REVERTED TO TENTATIVE, 1936.

Properties

1. The tar shall conform to the following requirements:

(*a*) Water........................not more than 2.00 per cent

(*b*) Specific viscosity, Engler,[2] 50 cc. at 40°C. (104° F)...8 to 35

(*c*) Distillation test on water-free material:

Total Distillate, by weight, 0 to 170° C. (32 to 338° F.)	not more than 5.00 per cent
Total Distillate, by weight, 0 to 235° C. (32 to 455° F.)	not more than 20.00 "
Total Distillate, by weight, 0 to 270° C. (32 to 518° F.)	not more than 35.00 "
Total Distillate, by weight, 0 to 300° C. (32 to 572° F.)	not more than 45.00 "
Residue, by weight	not less than 55.00 "

(*d*) Softening point (Ring-and-Ball Method) of residue from distillation test......................not more than 60° C. (140° F.)

(*e*) Total Bitumen (Soluble in Carbon Disulfide).....................................not less than 95.00 per cent

Methods of Testing.

2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials, except as specified in Paragraph (*b*):

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-4 on Road and Paving Materials.

[2] Within the viscosity limits designated a material should be chosen to meet the local conditions of temperature, road conditions and climate. It is recommended that materials be called for under the following range and headings: Light 8-13, Medium 13-18, Heavy 18-25, Extra Heavy 25-35.

(*a*) ***Percentage of Water:*** **Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (A.S.T.M. Designation: D 95);**[1]

(*b*) *Specific Viscosity:*[2] Method contained in *Bulletin No. 1216*, U. S. Department of Agriculture, the instrument being standardized by the U. S. Bureau of Standards. The results shall be reported as specific viscosity compared with water at 25° C. (77° F.).

(*c*) *Distillation:* Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (A.S.T.M. Designation: D 20);[3]

(*d*) *Softening Point:* Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (A.S.T.M. Designation: D 36);[4]

(*e*) *Total Bitumen:* Standard Method of Test for the Determination of Bitumen (A.S.T.M. Designation: D 4).[5]

---

[1] 1936 Book of A.S.T.M. Standards, Part II, p. 997.

[2] The Engler test has not been standardized by the American Society for Testing Materials. Committees of the Society have under consideration the Saybolt Furol apparatus, which may be adopted later.

[3] 1936 Book of A.S.T.M. Standards, Part II, p. 1053.

[4] *Ibid.*, p. 1098.

[5] *Ibid.*, p. 1041.

TENTATIVE SPECIFICATIONS
FOR
HIGH-CARBON TAR FOR SURFACE TREATMENT, HOT APPLICATION[1]

A.S.T.M. Designation: D 108 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED AS TENTATIVE, 1921; ADOPTED IN AMENDED FORM, 1930;
REVERTED TO TENTATIVE, 1936.

Properties. 1. The tar shall conform to the following requirements:

(*a*) Water .... 0.00 per cent

(*b*) Float test at 32° C. (89.6° F.) .... 60 to 150 sec.

(*c*) Distillation test:

Total Distillate, by weight, 0 to 170° C. (32 to 338° F.)..................	not more than	1.00 per cent
Total Distillate, by weight, 0 to 235° C. (32 to 455° F.)..................	not more than 10.00	"
Total Distillate, by weight, 0 to 270° C. (32 to 518° F.)..................	not more than 15.00	"
Total Distillate, by weight, 0 to 300° C. (32 to 572° F.)..................	not more than 25.00	"
Residue, by weight..................	not less than 75.00	"

(*d*) Specific gravity at 38° C. (100.4° F.) of total distillate to 300° C. (572° F.).................................not less than 1.02

(*e*) Softening point (Ring-and-Ball Method) of residue from distillation test.....................not more than 65° C. (149° F.)

(*f*) Total Bitumen (Soluble in Carbon Disulfide)[2]............. ....78 to 95 per cent

Methods of Testing. 2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-4 on Road and Paving Materials.

[2] The specification range for total bitumen covers a wide variety of materials. If products from vertical retort or low-carbon coke-oven tars are desired, a range of 88 to 95 per cent should be specified. If high-carbon coke-oven or mixtures of coke-oven and gas-house tars are desired, a range of 78 to 83 per cent should be specified.

(*a*) *Percentage of Water:* Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (A.S.T.M. Designation: D 95);[1]

(*b*) *Float Test:* Standard Method of Float Test for Bituminous Materials (A.S.T.M. Designation: D 139);[2]

(*c*) *Distillation:* Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (A.S.T.M. Designation: D 20);[3]

(*d*) *Softening Point:* Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (A.S.T.M. Designation: D 36);[4]

(*e*) *Total Bitumen:* Standard Method of Test for the Determination of Bitumen (A.S.T.M. Designation: D 4).[5]

---

[1] 1936 Book of A.S.T.M. Standards, Part II, p. 997.

[2] *Ibid.*, p. 1061.

[3] *Ibid.*, p. 1053.

[4] *Ibid.*, p. 1098.

[5] *Ibid.*, p. 1041.

TENTATIVE SPECIFICATIONS
FOR
LOW-CARBON TAR FOR SURFACE TREATMENT, HOT APPLICATION[1]

A.S.T.M. Designation: D 109 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED AS TENTATIVE, 1921; ADOPTED IN AMENDED FORM, 1930;
REVERTED TO TENTATIVE, 1936.

Properties. 1. The tar shall conform to the following requirements:

(*a*) Water....................................0.00 per cent

(*b*) Float test at 32° C. (89.6° F.)..................60 to 150 sec.

(*c*) Distillation test:

Total Distillate, by weight, 0 to 170° C.
(32 to 338° F.)..................not more than 1.00 per cent
Total Distillate, by weight, 0 to 235° C.
(32 to 455° F.)..................not more than 4.00 "
Total Distillate, by weight, 0 to 270° C.
(32 to 518° F.)..................not more than 13.00 "
Total Distillate, by weight, 0 to 300° C.
(32 to 572° F.)..................not more than 26.00 "
Residue, by weight.................. not less than 74.00 "

(*d*) Softening point (Ring-and-Ball Method) of residue from distillation test.......................not more than 65° C. (149° F.)

(*e*) Total Bitumen (Soluble in Carbon Disulfide)........ ......
............................not less than 95 per cent

Methods of Testing. 2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Percentage of Water:* Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (A.S.T.M. Designation: D 95);[2]

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-4 on Road and Paving Materials.

[2] 1936 Book of A.S.T.M. Standards, Part II, p. 997.

(*b*) *Float Test:* Standard Method of Float Test for Bituminous Materials (A.S.T.M. Designation: D 139);[1]

(*c*) *Distillation:* Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (A.S.T.M. Designation: D 20);[2]

(*d*) *Softening Point:* Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (A.S.T.M. Designation: D 36);[3]

(*e*) *Total Bitumen:* Standard Method of Test for the Determination of Bitumen (A.S.T.M. Designation: D 4).[4]

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 1061.

[2] *Ibid.*, p. 1053.

[3] *Ibid.*, p. 1098.

[4] *Ibid.*, p. 1041.

TENTATIVE METHODS OF TESTING EMULSIFIED ASPHALTS[1]

A.S.T.M. Designation: D 244 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1926; REVISED, 1928, 1933, 1934, 1935, 1936.

Scope

1. These methods are intended for the examination of asphalt emulsions composed, principally, of a semisolid or liquid asphaltic base, water and an emulsifying agent.

VISCOSITY

2. The viscosity of emulsified asphalt shall be determined by means of the Saybolt Furol viscosimeter.

Apparatus

3. The following apparatus will be required:

(*a*) *Viscosimeter.*—A Saybolt Furol viscosimeter conforming to the requirements specified in the Standard Method of Test for Viscosity by Means of the Saybolt Viscosimeter (A.S.T.M. Designation: D 88) of the American Society for Testing Materials.[2]

(*b*) *Sieve.*—A No. 20 sieve of the U. S. Standard Sieve Series, of iron wire cloth, framed or unframed, optional, conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials.[3]

Procedure

4. (*a*) The viscosity determination shall be made at 77 F. (25 C.) and shall be expressed in seconds, Saybolt Furol, being the time in seconds for the delivery of 60 ml. of emulsion.

(*b*) While the Saybolt Furol viscosimeter is not used for petroleum products and lubricants when the time of flow is less than 25 sec., this instrument is satisfactory for testing emulsified asphalt when the time of flow is not less than 20 sec.

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[1] Under the standardization procedure of the Society, these methods are under the joint jurisdiction of A.S.T.M. Committee D-4 on Road and Paving Materials and Committee D-8 on Bituminous Waterproofing and Roofing Materials.

[2] 1936 Book of A.S.T.M. Standards, Part II, p. 982.

[3] *Ibid.*, p. 1413.

(*c*) *Preparation of Sample.*—The sample shall be stirred thoroughly without incorporating bubbles in it and then poured into a 4-oz. bottle. The bottle shall then be placed in the water bath at 77 F. (25 C.) for 30 min. and the sample then mixed in the bottle by inverting several times, slowly enough to prevent bubble formation. The sample shall then be poured into the viscosity tube through a 20-mesh strainer, allowing a small portion to flow through the outlet tube to waste. The cork shall then be placed in position, the tube filled and without again stirring the sample the viscosity shall be determined as described in the Standard Method of Test for Viscosity by Means of the Saybolt Viscosimeter (A.S.T.M. Designation: D 88) of the American Society for Testing Materials.[1]

DISTILLATION

Apparatus

5. The following apparatus will be required:

(*a*) *Iron Still.*—The iron still shall be approximately 6 by 3½ in. in inside diameter with adjustable ring burner with holes on the inner periphery to fit around the outside of the still.

NOTE.—A modification of this still is shown in Fig. 2. It consists of the regular still with an expansion chamber superimposed thereon. Two additional ring burners are required, one approximately 6 in. in inside diameter with the holes bored on the inside periphery, and one approximately 2 in. in diameter with the holes bored on top.

(*b*) *Connecting Apparatus.*—A connecting tube, tin shield, condenser trough, condenser tube and graduated cylinder, as shown in Fig. 1.

(*c*) *Thermometer.*—A thermometer graduated from 30 to 580 F. (0 to 300 C.), conforming to the requirements of the Low-Distillation Thermometer specified in the Standard Method of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (A.S.T.M. Designation: D 86) of the American Society for Testing Materials.[2]

NOTE.—The details of the assembly of apparatus for the distillation test are illustrated in Fig. 1.

Procedure

6. (*a*) Exactly 200 g. of a well-mixed and representative sample of the emulsion shall be placed in the previously weighed iron still (including lid, clamp, thermometer and gasket, if gasket is used).

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 982.

[2] *Ibid.*, p. 870.

(*b*) A gasket of oiled paper may be used between the still and its cover or the joint ground to a tight fit. The cover shall be clamped securely on the still.

(*c*) The thermometer shall be inserted through the small hole in the cover, using a cork stopper, so that the end of the bulb is ¼ in. from the bottom of the still.

(*d*) The ring burner shall be placed around the still and the heat applied by this means to the top of the still. Just enough heat from a bunsen burner shall also be applied to the connecting tube to prevent condensation of water in this tube.

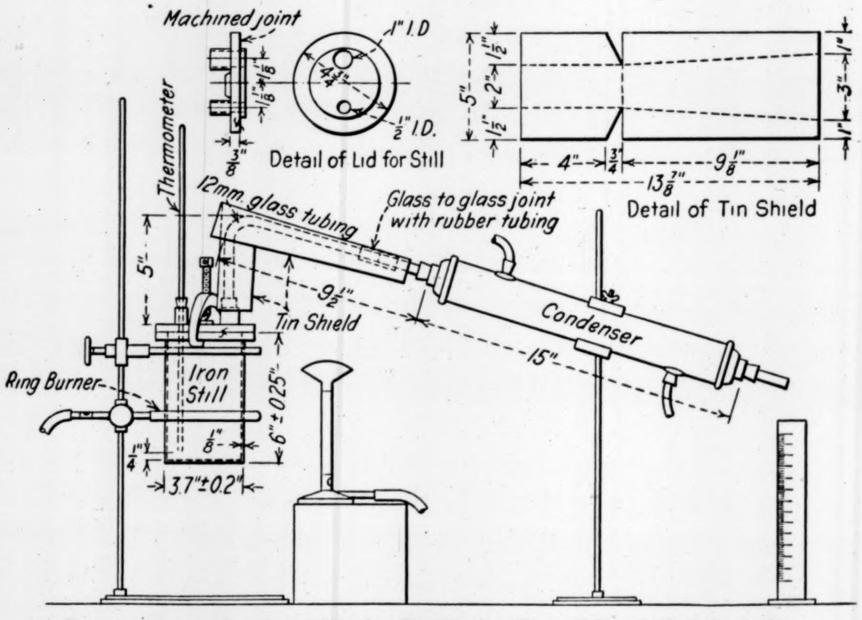

Machined joint
1" I.D
4¾"
1⅛"
1⅛"
½" I.D.
⅜"
Detail of Lid for Still
5"
1½"
2"
1½"
1"
3"
1"
4"
¾
9⅛"
13⅞"
Detail of Tin Shield
Thermometer
12mm. glass tubing
Glass to glass joint with rubber tubing
5"
9½"
Tin Shield
Condenser
15"
Ring Burner
Iron Still
6"±0.025"
⅛"
¼"
3.7"±0.2"

FIG. 1.—Apparatus Assembly for Distillation Test of Emulsified Asphalts.

(*e*) After practically all the condensate has been removed from the still and the temperature of the residue has reached 250 F. (121 C.), the position of the heat from the ring burner shall be lowered to midway of the still and held there until the thermometer reaches 349 F. (176 C.). The burner shall then be rapidly lowered to within ½ in. of the bottom of the still and the temperature increased to and maintained at 500 F. (260 C.) for 15 min. This latter period of heating is necessary to insure a smooth homogeneous residue in the still.

(*f*) At the expiration of the heating period at the maximum temperature, the still and accessories shall again be weighed as described in Paragraph (*a*) and the percentage residue calculated and reported. The cover shall then be removed from the still and suitable portions of the residue shall be poured immediately into suitable molds and containers for making the required tests. The residue in the molds and containers shall be permitted to cool, uncovered, to laboratory room temperature and thereafter tested as described in Sections 26 to 30, inclusive.

NOTE.—When it appears impossible to distill an emulsified asphalt in the still described in Section 5 (*a*) due to excessive foaming of the emulsion, then the modified still shown in Fig. 2 should be substituted for the still shown in Fig. 1 and the following procedure followed: Place the 6-in. burner around the larger diameter of the still near its top. This serves as a support. Place the 4-in. burner immediately beneath the flare and the 2-in. burner not less than 2 in. below the bottom. Distillation is started with only the 2-in. burner lighted. Practically all of the distillate should be over in about 45 min. When the distillation apparently stops, light the two larger ring burners and adjust to a low flame. Distillation resumes and when it stops again increase the heat by adjusting the flame of the 2-in. burner. When the temperature can be read upon the thermometer, increase the rate of heating by raising the flame on both the 2 and 4-in. burners and bring the temperature to 500 F. (260 C.).

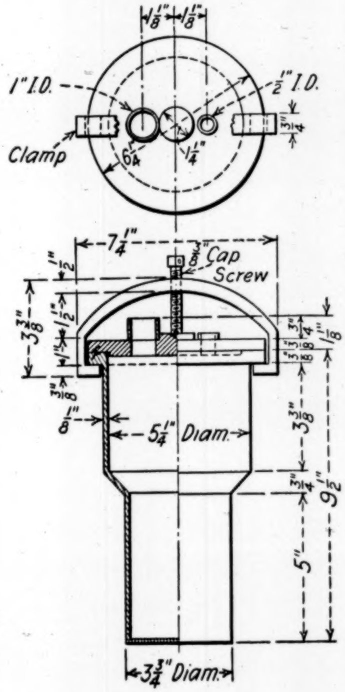


FIG. 2.—Iron Still for Use with Badly Foaming Emulsions.

If any evidence is noted of the emulsion beginning to foam over in the delivery tube, remove the 2-in. burner quickly and raise a pan of water so as to immerse the still bottom to a depth of about 2 in. for a moment which will check the foaming. Upon resumption of heating watch delivery tube carefully and repeat treatment if necessary.

When the residue has reached and remained at 500 F. (260 C.) for 15 min., proceed as described in Section 6 for the regular still. While the distillation should be completed in not less than 1 hr. nor more than 1½ hr. from the first application of heat to the still, the maximum stated is not mandatory as a longer time may be required in some cases to avoid foaming of the emulsion into the condenser.

If the residue in the still prior to pouring the ductility and penetration specimens appears granular or heterogeneous in any way, stir with a spatula until the material runs from the spatula in strings instead of drops, and then pour. Should the residue then appear granular and heterogeneous, the test shall be rejected and the distillation repeated as previously described with the exception that the still temperature at 500 F. (260 C.) shall be maintained for a longer time than 15 min. until the desired condition of the residue is obtained.

DETERMINATION OF WATER

Scope

7. This method of test determines water existing in a sample of bituminous emulsion by distilling the sample with a volatile solvent.

Apparatus

8. (*a*) The apparatus shall consist of a metal still or glass flask, heated by suitable means and provided with a reflux condenser discharging into a trap connected to the still or flask. The trap serves to collect and measure the condensed water and to return the solvent to the still. The type of distilling apparatus used is not an essential feature of this method.

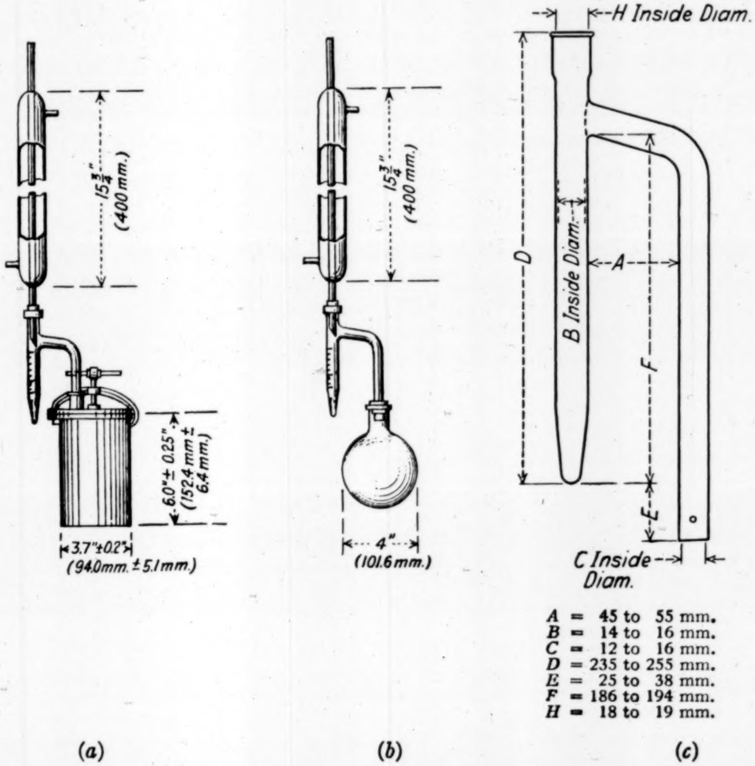
(*b*) *Metal Still.*—The metal still, Fig. 3 (*a*), shall be a vertical cylindrical vessel, preferably of copper, having a faced flange at the top to which the head is tightly attached by means of a clamp. The head shall be of metal, preferably of brass or copper, and be provided with a tubulation 1 in. in inside diameter.

(*c*) *Glass Still.*—The glass flask, Fig. 3 (*b*), shall be of the short neck, round-bottom type, made of well-annealed glass, having an approximate capacity of 500 ml.

(*d*) *Heat Source.*—The burner used with the metal still shall be a ring gas burner 100 mm. (4 in.) in inside diameter. With the glass flask, an ordinary gas burner or electric heater may be used as the source of heat.

(*e*) *Condenser.*—The condenser shall be of the water-cooled, reflux, glass-tube type, having a condenser jacket not less than 400 mm. (15¾ in.) in length with an inner tube 9.5 to 12.7 mm. (⅜ to ½ in.) in outside diameter. The end of the condenser to be inserted in the trap shall be ground off at an angle of 30 deg. ± 5 deg. from the vertical axis of the condenser.

(*f*) *Trap*.—The trap shall be made of well-annealed glass constructed in accordance with Fig. 3 (*c*) and shall be graduated from 0 to 25 ml., in 0.1-ml. divisions. The tolerance of the graduations between 0 and 2 ml. shall be ±0.5 ml. and between 2 and 25 ml. shall be ±0.1 ml.


15 3/4" (400 mm.)
6.0" ± 0.25" (152.4 mm ± 6.4 mm.)
3.7" ± 0.2" (94.0 mm. ± 5.1 mm.)
15 3/4" (400 mm.)
4" (101.6 mm.)
H Inside Diam.
D
B Inside Diam.
A
F
E
C Inside Diam.
A = 45 to 55 mm.
B = 14 to 16 mm.
C = 12 to 16 mm.
D = 235 to 255 mm.
E = 25 to 38 mm.
F = 186 to 194 mm.
H = 18 to 19 mm.

(*a*) (*b*) (*c*)

Fig. 3.—Apparatus for Determining Water.

Solvent

9. The solvent used when testing bituminous emulsions shall be a coal-tar naphtha or a light oil and shall conform to the following distillation requirements, determined in accordance with the Standard Method of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (A.S.T.M. Designation: D 86) of the American Society for Testing Materials:[1]

98 per cent shall distill between 248 F. (120 C.) and 482 F. (250 C.).

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 870.

Sample

10. The sample shall be thoroughly representative of the material to be tested and the portion of the sample used for the test shall be thoroughly representative of the sample itself. Deviation from this requirement shall not be permitted.

NOTE.—The difficulties in obtaining proper representative samples for this determination are unusually great so that the importance of sampling cannot be too strongly emphasized.

Procedure

11. (*a*) When the material to be tested contains less than 25 per cent of water, exactly a 100-g. sample shall be placed in the still or flask. When the material contains more than 25 per cent of water, the sample shall be 50 g. The sample to be tested shall be thoroughly mixed with an equal volume of solvent by swirling, proper care being taken to avoid any loss of material.

(*b*) The connections between the still or flask, trap and condenser shall be made by means of tight-fitting corks as shown in Fig. 3 (*a*) and (*b*). The end of the condenser inserted in the trap shall be adjusted to that position which will allow the end to be submerged to a depth of not more than 1 mm. (0.04 in.) below the surface of the liquid in the trap after distillation conditions have been established. When the metal still is used, a heavy paper gasket moistened with the solvent shall be inserted between the lid and flange before attaching the clamp. A loose cotton plug shall be inserted in the top of the condenser tube to prevent condensation of atmospheric moisture in the condenser tube.

(*c*) Heat shall then be applied and so regulated that the condensed distillate falls from the end of the condenser at the rate of from 2 to 5 drops per sec. The ring burner used with the metal still shall be placed about 3 in. above the bottom of the still at the beginning of the distillation and gradually lowered as the distillation proceeds.

(*d*) The distillation shall be continued at the specified rate until no water is visible on any part of the apparatus except at the bottom of the trap. This operation usually requires less than 1 hr. A persistent ring of condensed water in the condenser tube shall be removed by increasing the rate of distillation for a few minutes.

Calculation and Reporting of Results

12. The volume of condensed water measured in the trap at room temperature multiplied by 100 and divided by the weight of sample used, shall be the percentage of water and shall be reported as "...... per cent water by weight, A.S.T.M. method."

Accuracy

13. The accuracy to be expected with this method is that duplicate determinations of water should not differ from each other by more than one division on the trap.

SETTLEMENT

Apparatus

14. The following apparatus will be required:

(*a*) *Cylinders.*—Two glass cylinders of 500-ml. capacity with pressed or molded glass base and cork or glass stoppers. The outside diameter shall be 5.0 cm. ±0.5 cm. and the cylinders shall be graduated at each 5-ml. interval to the 500-ml. mark.

(*b*) *Glass Pipette.*—A syphon, glass tube pipette, 60-ml. capacity, form optional.

Procedure

15. (*a*) A 500-ml. sample, representative of the emulsion, shall be placed in each of two glass cylinders. The cylinder shall be stoppered air-tight and stood aside unmolested, at laboratory air temperature for 5 days. After standing for this 5-day period, approximately the first 55 ml. of emulsion shall be removed by means of the pipette or syphon from the top of each cylinder without disturbing the balance of their contents. Exactly 50 g. of each of the two samples, after each has been thoroughly mixed separately, shall be weighed into separate 600-ml. low-form glass beakers and the asphaltic residue determined by evaporation at 325 F. (163 C.) for 3 hr. in the apparatus described in the Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (A.S.T.M. Designation: D 6) of the American Society for Testing Materials.[1]

(*b*) After removal of the first sample, approximately the next 390 ml. shall be syphoned off from each of the cylinders. The residue remaining in the cylinders shall be mixed thoroughly and exactly 50 g. shall be weighed out from each of them and the amount of asphaltic residue (all sediment, if any, included) shall be determined by evaporation as described in Paragraph (*a*) for the two top samples.

(*c*) The numerical difference between the average percentage of asphaltic residue from the two top samples and the average percentage found in the two bottom samples shall be recorded.

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 1071.

DEMULSIBILITY

Apparatus and Reagents

16. The following apparatus and reagents will be required:

(*a*) *Sieves.*—Three No. 14 sieves of the U. S. Standard Sieve Series, of iron wire cloth, unframed, approximately 5-in. square, conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials.[1]

(*b*) *Beakers.*—Three glass beakers of 600-ml. capacity each.

(*c*) *Glass Rods.*—Three glass rods, rounded ends, approximately $\frac{5}{16}$ in. in diameter.

(*d*) *Burette.*—A 50-ml. glass burette graduated in 0.1 ml.

(*e*) *Calcium Chloride Solution (0.02 N).*

(*f*) *Calcium Chloride Solution (0.10 N).*

Procedure

17. (*a*) The percentage of residue shall be determined by distillation as described in Section 6.

(*b*) The weight of each assembly of beaker, rod and sieve shall be recorded.

(*c*) Exactly 100 g. of the emulsified asphalt shall be weighed into each of three 600-ml. tared beakers. Over a period of approximately 2 min., 35 ml. of 0.02 *N* $CaCl_2$ solution (if quick-setting emulsion is being tested) or 50 ml. of 0.10 *N* $CaCl_2$ solution (if mixing type emulsion is being tested) shall be added to each beaker from a burette. While adding the solution of $CaCl_2$, the contents of the beaker shall be stirred continuously and vigorously, kneading lumps against the sides of the beaker to insure thorough mixing of the reagent with the emulsion. This operation shall be performed after bringing the weighed sample of emulsion and the reagent to the standard temperature of 77 F. ± 1.0 F. (25 C. ± 0.5 C.).

(*d*) One of the wire sieves shall be fitted over a beaker or other suitable vessel and the mixture of emulsion and reagent poured through the sieve. The beaker, containing the sample and glass rod, shall be rinsed with distilled water. All lumps shall be kneaded and broken up and the washing of the beaker, rod and sieve shall be continued until there is no longer any appreciable color imparted to the wash water. After washing as directed, the beaker, rod and sieve used in each individual test shall be placed in a drying oven and dried at 325 F. (163 C.) to constant weight.

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 1413.

Calculation

18. The total weight thus obtained less the total tare weight of the beaker, rod and sieve shall be the weight of the residue by the demulsibility test. The ratio of the average weight in grams from three tests of each individual sample of emulsified asphalt, A, to the weight in grams of residue per 100 g. of emulsion, B, obtained in the test for residue by distillation described in Section 6 multiplied by 100, shall be recorded as the percentage of demulsibility of the sample tested:

$$\text{Percentage Demulsibility} = \frac{A}{B} \times 100$$

SIEVE TEST

Apparatus and Reagents

19. The following apparatus and reagents will be required:

(*a*) *Sieve.*—A No. 20 sieve, 3-in. in diameter with metal frame, of the U. S. Standard Sieve Series, conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials.[1]

(*b*) *Pan.*—A tin box cover or shallow metal pan of appropriate size to fit over the bottom of the standard sieve.

(*c*) *Sodium Oleate Solution (2 per cent).*—Prepare a 2 per cent solution of pure sodium oleate in distilled water.

Procedure

20. The weight of the sieve and pan shall be recorded and the wire cloth of the No. 20 sieve shall then be wet with the sodium oleate solution (2 per cent). Exactly 1000 g. of the emulsified asphalt shall then be weighed and poured through the wire sieve, the container and the residue on the sieve being washed thoroughly with the sodium oleate solution until the washings run clear. The pan shall then be placed under the sieve and heated for 2 hr. in a drying oven whose interior temperature is 220 F. (105 C.), then cooled in a desiccator and weighed.

Calculation

21. The total weight of the sieve, pan, and residue in grams less the combined tare weight of the sieve and pan, is the weight of the residue by the sieve test. The percentage of residue in the emulsion shall be calculated on the basis of this weight.

MISCIBILITY WITH WATER

NOTE.—This test is not applicable to the so-called quick-setting type of emulsions.

Procedure

22. To about 50 ml. of the emulsion shall be gradually added about 150 ml. of distilled water, stirring the mixture while adding the

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 1413.

water. The temperature is not important but should be between 21 and 25 C. (70 and 77 F.). The mixture shall be allowed to stand for 2 hr. and then examined for any appreciable coagulation of the asphalt content of the emulsion.

COATING TEST

NOTE.—This test is applicable only for emulsions containing a base of asphalt of semisolid consistency. It is not applicable to the so-called quick-setting type of emulsions.

Apparatus and Reagents

23. The following apparatus and reagents will be required:

(*a*) *Screens.*—A standard ¾-in. screen and ¼-in. screen conforming to the requirements of the Standard Specifications for Round-Hole Screens for Testing Purposes (A.S.T.M. Designation: E 17) of the American Society for Testing Materials.[1]

(*b*) *Spatula.*—A steel spatula or its equivalent, blade approximately 8 in. in length.

(*c*) *Dish.*—A round-bottom, iron dish or a kitchen saucepan, approximately 1-qt. capacity.

(*d*) A supply of reference stone (hard limestone, trap rock, or other type) which has been washed with water and dried before using. The grading of this stone shall be such that it will all pass through a standard ¾-in. screen and not more than 5 per cent will pass through a ¼-in. screen.

NOTE.—Each laboratory shall select its own reference stone supply, the source of which is not apt to change. This is to obviate rapid changes in the character of reference stone used in any one laboratory.

Procedure

24. (*a*) Exactly 465 g. of the washed and dried graded stone, shall be weighed and placed in the metal pan.

(*b*) A 35-g. sample of the emulsion shall then be added to the stone in the pan and mixed vigorously with the spatula for 3 min.

(*c*) Record whether or not there is appreciable separation of the asphaltic base from the water of the emulsion and whether or not the stone is uniformly and thoroughly coated with the emulsion.

FREEZING TEST

Procedure

25. (*a*) Approximately 400 g. of the emulsion shall be placed in a clean metal container, such as a 1-pt. press-top tin.

(*b*) The emulsion in the closed container shall be exposed to a temperature of 0 F. (−17.7 C.) for twelve consecutive hours.

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 1411.

(*c*) At the expiration of the freezing period, the emulsion shall be permitted to thaw by exposure of the container to the temperature of the laboratory.

(*d*) After the first operation of freezing and thawing, the procedure shall be repeated twice, so that the emulsion will have been subjected to three cycles of freezing and thawing.

(*e*) After the third cycle, the emulsion may be homogeneous or may have separated into distinct layers which cannot be rendered homogeneous by stirring at laboratory temperature.

(*f*) The result of this test shall be reported as either "Homogeneous" or "Broken."

PENETRATION OF RESIDUE

26. The penetration shall be determined upon a representative portion of the residue in accordance with the Standard Method of Test for Penetration of Bituminous Materials (A.S.T.M. Designation: D 5) of the American Society for Testing Materials.[1]

SOLUBILITY OF RESIDUE

27. The solubility in carbon disulfide shall be determined upon a representative portion of the residue in accordance with the Standard Method of Test for the Determination of Bitumen (A.S.T.M. Designation: D 4) of the American Society for Testing Materials.[2]

DUCTILITY OF RESIDUE

28. The ductility shall be determined upon a representative portion of the residue in accordance with the Standard Method of Test for Ductility of Bituminous Materials (A.S.T.M. Designation: D 113) of the American Society for Testing Materials.[3]

SPECIFIC GRAVITY OF RESIDUE

29. The specific gravity shall be determined upon a representative portion of the residue in accordance with the Standard Method of Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements and Soft Tar Pitches (A.S.T.M. Designation: D 70) of the American Society for Testing Materials.[4]

ASH IN RESIDUE

30. The ash shall be determined upon a representative portion of the residue in accordance with the Rapid Routine Method of Ash Determination, as described in the Standard Methods of Analysis of Grease (A.S.T.M. Designation: D 128) of the American Society for Testing Materials.[5]

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 1080.

[2] *Ibid.*, p. 1041.

[3] *Ibid.*, p. 1058.

[4] *Ibid.*, p. 1110.

[5] *Ibid.*, p. 926.

TENTATIVE SPECIFICATIONS
FOR
ASPHALT FOR USE IN DAMP-PROOFING AND WATERPROOFING ABOVE GROUND LEVEL[1]

A.S.T.M. Designation: D 144 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued as Tentative, 1922; Adopted in Amended Form, 1925;
Reverted to Tentative, 1936.

Scope.

1. These specifications cover asphalt suitable for use as a mopping-coat in damp-proofing, or as a plying-cement in the construction of a membrane system of waterproofing above ground level, where not exposed to a temperature exceeding 46° C. (115° F.).[2] It may be used below ground level.

2. The grade of asphalt covered in these specifications is suitable for damp-proofing and waterproofing railroad bridges, tanks, retaining walls, culverts, dams, conduits, etc.

SAMPLING

Sampling.

3. The sampling shall be performed in accordance with the Standard Methods of Sampling Bituminous Materials (A.S.T.M. Designation: D 140) of the American Society for Testing Materials.[3]

PROPERTIES

Properties.

4. The asphalt shall be homogeneous and free from water. It shall conform to the following requirements:

(*a*) Softening point by the Ring-and-Ball method.................150 to 170° F. (65.5 to 76.7° C.)

(*b*) Penetration at 46.1° C. (115° F.), 50 g., 5 sec...............................not more than 100

Penetration at 25° C. (77° F.), 100 g., 5 sec......................................25 to 50

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-8 on Bituminous Waterproofing and Roofing Materials.

[2] Such asphalt is not intended to be heated above 450° F. (232.2° C.) during its application.

[3] 1936 Book of A.S.T.M. Standards, Part II, p. 1088.

Penetration at 0° C. (32° F.), 200 g., 60 sec. .... **not less than 10**

(c) Flash point (open cup) .... **not less than 400° F. (204.4° C.)**

(d) Loss on heating at 163° C. (325° F.), 50 g., 5 hr .... **not more than 1 per cent**

(e) Penetration at 25° C. (77° F.), 100 g., 5 sec., of residue after heating at 163° C. (325° F.) as compared with penetration of asphalt before heating .... **not less than 60 per cent**

(f) Ductility at 25° C. (77° F.) .... **not less than 15 cm.**

(g) Insoluble in carbon disulfide .... **not more than 1 per cent**

METHODS OF TESTING

Methods of Testing.

5. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Softening Point:* Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (A.S.T.M. (Designation: D 36).[1]

(*b*) *Penetration:* Standard Method of Test for Penetration of Bituminous Materials (A.S.T.M. Designation: D 5).[2]

(*c*) *Flash Point:* Standard Method of Test for Flash and Fire Points by Means of Open Cup (A.S.T.M. Designation: D 92).[3]

(*d*) *Loss on Heating:* Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (A.S.T.M. Designation: D 6).[4]

(*e*) *Ductility:* Standard Method of Test for Ductility of Bituminous Materials (A.S.T.M. Designation: D 113).[5]

(*f*) *Insoluble in Carbon Disulfide:* Standard Method of Test for the Determination of Bitumen (A.S.T.M. Designation: D 4).[6]

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 1098.

[2] *Ibid.*, p. 1080.

[3] *Ibid.*, p. 892.

[4] *Ibid.*, p. 1071.

[5] *Ibid.*, p. 1058.

[6] *Ibid.*, p. 1041.

TENTATIVE SPECIFICATIONS
FOR
ASPHALT FOR USE IN DAMP-PROOFING AND WATERPROOFING BELOW GROUND LEVEL[1]

A.S.T.M. Designation: D 40 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED AS TENTATIVE, 1917; ADOPTED IN AMENDED FORM, 1925;
REVERTED TO TENTATIVE, 1936.

Scope. 1. These specifications cover asphalt suitable for use as a mopping-coat in damp-proofing, or as a plying-cement in the construction of a membrane system of waterproofing below ground level, under uniformly moderate temperature conditions both during the process of installation and during service.[2]

2. The grade of asphalt covered in these specifications is suitable for damp-proofing and waterproofing foundations, tunnels, subways, etc.

SAMPLING

Sampling. 3. The sampling shall be performed in accordance with the Standard Methods of Sampling Bituminous Materials (A.S.T.M. Designation: D 140) of the American Society for Testing Materials.[3]

PROPERTIES

Properties. 4. The asphalt shall be homogeneous and free from water. It shall conform to the following requirements:

(*a*) Softening point by the Ring-and-Ball method.................115 to 145° F. (46.1 to 62.7° C.)
(*b*) Penetration at 25° C. (77° F.), 100 g., 5 sec...................................50 to 100
(*c*) Flash point (open cup).......not less than 347° F. (175° C.)
(*d*) Loss on heating at 163° C. (325° F.), 50 g., 5 hr....................not more than 2 per cent

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-8 on Bituminous Waterproofing and Roofing Materials.

[2] Such asphalt is not intended to be heated above 400° F. (204.4° C.) during its application.

[3] 1936 Book of A.S.T.M. Standards, Part II, p. 1088.

(*e*) **Penetration at 25° C. (77° F.), 100 g., 5 sec., of residue after heating at 163° C. (325° F.) as compared with penetration of asphalt before heating.........................not less than 60 per cent**

(*f*) **Ductility at 25° C. (77° F.)..............not less than 30 cm.**

(*g*) **Insoluble in carbon disulfide........not more than 5 per cent**

METHODS OF TESTING

Methods of Testing.

5. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) ***Softening Point:*** Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (A.S.T.M. **Designation: D 36).**[1]

(*b*) ***Penetration:*** Standard Method of Test for Penetration of Bituminous Materials (A.S.T.M. Designation: D 5).[2]

(*c*) ***Flash Point:*** Standard Method of Test for Flash and Fire Points by Means of Open Cup (A.S.T.M. Designation: D 92).[3]

(*d*) ***Loss on Heating:*** Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (A.S.T.M. Designation: D 6).[4]

(*e*) *Ductility:* Standard Method of Test for Ductility of Bituminous Materials (A.S.T.M. Designation: D 113).[5]

(*f*) ***Insoluble in Carbon Disulfide:*** Standard Method of Test for the Determination of Bitumen (A.S.T.M. Designation: D 4).[6]

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[1] 1936 Book of A.S.T.M. Standards, **Part II**, p. 1098.

[2] *Ibid.*, p. 1080.

[3] *Ibid.*, p. 892.

[4] *Ibid.*, p. 1071.

[5] *Ibid.*, p. 1058.

[6] *Ibid.*, p. 1041.

TENTATIVE SPECIFICATIONS
FOR
HIGH-BITUMEN COAL-TAR PITCH FOR USE IN CONSTRUCTING BUILT-UP ROOFS SURFACED WITH SLAG OR GRAVEL[1]

A.S.T.M. Designation: D 252 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued as Tentative, 1926; Adopted, 1927; Reverted to Tentative, 1936.

Scope.

1. These specifications cover high-bitumen coal-tar pitch intended for use as a mopping coat in the construction of built-up roofs surfaced with slag or gravel on inclines not exceeding 3 in. to the foot over boards and 1 in. to the foot over concrete, in connection with the Standard Specifications for Coal-Tar Saturated Roofing Felt for Use in Waterproofing and in Constructing Built-Up Roofs (A.S.T.M. Designation: D 227) of the American Society for Testing Materials.[2]

SAMPLING

Sampling.

2. The sampling shall be performed in accordance with the Standard Methods of Sampling Bituminous Materials (A.S.T.M. Designation: D 140) of the American Society for Testing Materials.[3]

PROPERTIES

Properties.

3. The high-bitumen coal-tar pitch shall be homogeneous and shall conform to the following requirements:

(*a*) Water....................................0.0 per cent
(*b*) Specific gravity at 25° C. (77° F.)..........1.22 to 1.32
(*c*) Softening Point (Cube-in-Water Method)...140 to 150° F. (60.0 to 65.5° C.)

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[1] **Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-8 on Bituminous Waterproofing and Roofing Materials.**

[2] 1936 Book of A.S.T.M. Standards, Part II, p. 1140.

[3] *Ibid.*, p. 1088.

(*d*) **Distillation Test:**

Total distillate, by weight, 0.0 to 300° C. (32 to 572° F.)..........not more than 12 per cent
Residue, by weight..................not less than 88 per cent

(*e*) Specific gravity at 38°/25° C. (100°/77° F.) of total distillate to 300° C. (572° F.).......................not less than 1.03
(*f*) Ductility at 25° C. (77° F.)........not less than 50 cm.
(*g*) Total bitumen (Soluble in Carbon Disulfide)........................78 to 85 per cent
(*h*) Ash on incineration.........not more than 0.5 per cent

METHODS OF TESTING

4. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials: **Methods of Testing.**

(*a*) *Percentage of Water:* Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (A.S.T.M. Designation: D 95).[1]
(*b*) *Specific Gravity:* Standard Method of Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements and Soft Tar Pitches (A.S.T.M. Designation: D 70).[2]
(*c*) *Softening Point:* Standard Method of Test for Softening Point of Tar Products (Cube-in-Water Method) (A.S.T.M. Designation: D 61).[3]
(*d*) *Distillation:* Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (A.S.T.M. Designation: D 20).[4]
(*e*) *Ductility:* Standard Method of Test for Ductility of Bituminous Materials (A.S.T.M. Designation: D 113).[5]
(*f*) *Soluble in Carbon Disulfide:* Standard Method of Test for the Determination of Bitumen (A.S.T.M. Designation: D 4).[6]
(*g*) *Ash:* Standard Methods of Laboratory Sampling and Analysis of Coal and Coke (A.S.T.M. Designation: D 271).[7]

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 997.
[2] *Ibid.*, p. 1110.
[3] *Ibid.*, p. 1103.
[4] *Ibid.*, p. 1053.
[5] *Ibid.*, p. 1058.
[6] *Ibid.*, p. 1041.
[7] *Ibid.*, p. 387.

TENTATIVE SPECIFICATIONS
FOR
HIGH-CARBON COAL-TAR PITCH FOR USE IN CONSTRUCTING BUILT-UP ROOFS SURFACED WITH SLAG OR GRAVEL[1]

A.S.T.M. Designation: D 251 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued as Tentative, 1926; Adopted, 1927; Reverted to Tentative, 1936.

Scope. 1. These specifications cover high-carbon coal-tar pitch intended for use as a mopping coat in the construction of built-up roofs surfaced with slag or gravel on inclines not exceeding 3 in. to the foot over boards and 1 in. to the foot over concrete, in connection with the Standard Specifications for Coal-Tar Saturated Roofing Felt for Use in Waterproofing and in Constructing Built-Up Roofs (A.S.T.M. Designation: D 227) of the American Society for Testing Materials.[2]

SAMPLING

Sampling. 2. The sampling shall be performed in accordance with the Standard Methods of Sampling Bituminous Materials (A.S.T.M. Designation: D 140) of the American Society for Testing Materials.[3]

PROPERTIES

Properties. 3. The high-carbon coal-tar pitch shall be homogeneous and shall conform to the following requirements:

(*a*) Water.................................. 0.0 per cent
(*b*) Specific gravity at 25° C. (77° F.)......... 1.25 to 1.34
(*c*) Softening Point (Cube-in-Water Method)..140 to 150° F. (60.0 to 65.5° C.)
(*d*) Distillation Test:
    Total distillate, by weight, 0.0 to 300° C. (32 to 572° F.)...........not more than 12 per cent
    Residue, by weight..................not less than 88 per cent

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-8 on Bituminous Waterproofing and Roofing Materials.

[2] 1936 Book of A.S.T.M. Standards, Part II, p. 1140.

[3] *Ibid.*, p. 1088.

(*e*) Specific gravity at 38°/25° C. (100°/ 77° F.) of total distillate to 300° C. (572° F.)........................not less than 1.03

(*f*) Ductility at 25° C. (77° F.)........not less than 50 cm.

(*g*) Insoluble in carbon disulfide......... 22 to 35 per cent

(*h*) Ash on incineration.........not more than 0.5 per cent

METHODS OF TESTING

Methods of Testing.

4. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Percentage of Water:* Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (A.S.T.M. Designation: D 95).[1]

(*b*) *Specific Gravity:* Standard Method of Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements and Soft Tar Pitches (A.S.T.M. Designation: D 70).[2]

(*c*) *Softening Point:* Standard Method of Test for Softening Point of Tar Products (Cube-in-Water Method) (A.S.T.M. Designation: D 61).[3]

(*d*) *Distillation:* Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (A.S.T.M. Designation: D 20).[4]

(*e*) *Ductility:* Standard Method of Test for Ductility of Bituminous Materials (A.S.T.M. Designation: D 113).[5]

(*f*) *Insoluble in Carbon Disulfide:* Standard Method of Test for the Determination of Bitumen (A.S.T.M. Designation: D 4).[6]

(*g*) *Ash:* Standard Methods of Laboratory Sampling and Analysis of Coal and Coke (A.S.T.M. Designation: D 271).[7]

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 997.

[2] *Ibid.*, p. 1110.

[3] *Ibid.*, p. 1103.

[4] *Ibid.*, p. 1053.

[5] *Ibid.*, p. 1058.

[6] *Ibid.*, p. 1041.

[7] *Ibid.*, p. 387.

TENTATIVE SPECIFICATIONS

FOR

HIGH-BITUMEN COAL-TAR PITCH FOR USE IN DAMP-PROOFING AND WATERPROOFING ABOVE GROUND LEVEL[1]

A.S.T.M. Designation: D 201 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED AS TENTATIVE, 1924; ADOPTED, 1925; REVERTED TO TENTATIVE, 1936.

Scope. 1. These specifications cover high-bitumen coal-tar pitch suitable for use as a mopping-coat in damp-proofing, or as a plying-cement in the construction of a membrane system of waterproofing above ground level, when not exposed to a temperature exceeding 46° C. (115° F.).

2. The grade of high-bitumen coal-tar pitch covered in these specifications is suitable for damp-proofing and waterproofing railroad bridges, tanks, retaining walls, culverts, dams, conduits, etc.

SAMPLING

Sampling. 3. The sampling shall be performed in accordance with the Standard Methods of Sampling Bituminous Materials (A.S.T.M. Designation: D 140) of the American Society for Testing Materials.[2]

PROPERTIES

Properties. 4. The coal-tar pitch shall be homogeneous and shall conform to the following requirements:

(*a*) Water.......................................0.0 per cent
(*b*) Specific gravity at 25° C. (77° F.).........1.22 to 1.31
(*c*) Softening Point (Cube-in-Water Method).............130 to 155° F. (54.4 to 68.3° C.)
(*d*) Distillation Test:

Total distillate, by weight, 0.0 to 300° C. (32 to 572° F.)...............not more than 12.0 per cent
Residue, by weight...............not less than 88.0 per cent

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-8 on Bituminous Waterproofing and Roofing Materials.

[2] 1936 Book of A.S.T.M. Standards, Part II, p. 1088.

(e) Specific gravity at 38°/25° C. (100°/77° F.) of total distillate to 300° C. (572° F.)......not less than 1.05

(f) Ductility at 25° C. (77° F.)........not less than 20 cm.

(g) Total Bitumen (Soluble in Carbon Disulfide)........................73 to 88 per cent

METHODS OF TESTING

5. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials: **Methods of Testing.**

(a) *Percentage of Water:* Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (A.S.T.M. Designation: D 95).[1]

(b) *Specific Gravity:* Standard Method of Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements and Soft Tar Pitches (A.S.T.M. Designation: D 70).[2]

(c) *Softening Point:* Standard Method of Test for Softening Point of Tar Products (Cube-in-Water Method) (A.S.T.M. Designation: D 61).[3]

(d) *Distillation:* Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (A.S.T.M. Designation: D 20).[4]

(e) *Ductility:* Standard Method of Test for Ductility of Bituminous Materials (A.S.T.M. Designation: D 113).[5]

(f) *Total Bitumen (Soluble in Carbon Disulfide):* Standard Method of Test for the Determination of Bitumen (A.S.T.M. Designation: D 4).[6]

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 997.

[2] *Ibid.*, p. 1110.

[3] *Ibid.*, p. 1103.

[4] *Ibid.*, p. 1053.

[5] *Ibid.*, p. 1058.

[6] *Ibid.*, p. 1041.

TENTATIVE SPECIFICATIONS
FOR
HIGH-BITUMEN COAL-TAR PITCH FOR USE IN DAMP-PROOFING AND WATERPROOFING BELOW GROUND LEVEL[1]

A.S.T.M. Designation: D 200 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued as Tentative, 1924; Adopted, 1925; Reverted to Tentative, 1936.

Scope. 1. These specifications cover high-bitumen coal-tar pitch suitable for use as a mopping-coat in damp-proofing or as a plying-cement in the construction of a membrane system of waterproofing below ground level, under uniformly moderate temperature conditions both during the process of installation and during service.

2. The grade of high-bitumen coal-tar pitch covered by these specifications is suitable for damp-proofing and waterproofing foundations, tunnels, subways, etc.

SAMPLING

Sampling. 3. The sampling shall be performed in accordance with the Standard Methods of Sampling Bituminous Materials (A.S.T.M. Designation: D 140) of the American Society for Testing Materials.[2]

PROPERTIES

Properties. 4. The coal-tar pitch shall be homogeneous and shall conform to the following requirements:

(*a*) Water	0.0 per cent
(*b*) Specific gravity at 25° C. (77° F.)	1.21 to 1.30
(*c*) Softening Point (Cube-in-Water Method)	110 to 140° F. (43.3 to 60° C.)
(*d*) Distillation Test:	
Total distillate, by weight, 0.0 to 300° C. (32 to 572° F.)	not more than 15.0 per cent
Residue, by weight	not less than 85.0 per cent

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-8 on Bituminous Waterproofing and Roofing Materials.

[2] 1936 Book of A.S.T.M. Standards, Part II, p. 1088.

(e) Specific gravity at 38°/25° C. (100°/77° F.) of total distillate to 300° C. (572° F.)......not less than 1.03

(f) Ductility at 25° C. (77° F.)........not less than 50 cm.

(g) Total Bitumen (Soluble in Carbon Disulfide)........................75 to 90 per cent

METHODS OF TESTING

Methods of Testing. 5. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(a) *Percentage of Water:* Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (A.S.T.M. Designation: D 95).[1]

(b) *Specific Gravity:* Standard Method of Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements and Soft Tar Pitches (A.S.T.M. Designation: D 70).[2]

(c) *Softening Point:* Standard Method of Test for Softening Point of Tar Products (Cube-in-Water Method) (A.S.T.M. Designation: D 61).[3]

(d) *Distillation:* Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (A.S.T.M. Designation: D 20).[4]

(e) *Ductility:* Standard Method of Test for Ductility of Bituminous Materials (A.S.T.M. Designation: D 113).[5]

(f) *Total Bitumen (Soluble in Carbon Disulfide):* Standard Method of Test for the Determination of Bitumen (A.S.T.M. Designation: D 4).[6]

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 997.

[2] *Ibid.*, p. 1110.

[3] *Ibid.*, p. 1103.

[4] *Ibid.*, p. 1053.

[5] *Ibid.*, p. 1058.

[6] *Ibid.*, p. 1041.

TENTATIVE SPECIFICATIONS

FOR

HIGH-CARBON COAL-TAR PITCH FOR USE IN DAMP-PROOFING AND WATERPROOFING ABOVE GROUND LEVEL[1]

A.S.T.M. Designation: D 145 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued as Tentative, 1922; Adopted in Amended Form, 1925;
Reverted to Tentative, 1936.

Scope.

1. These specifications cover high-carbon coal-tar pitch suitable for use as a mopping-coat in damp-proofing, or as a plying-cement in the construction of a membrane system of waterproofing above ground level, when not exposed to a temperature exceeding 46° C. (115° F.).[2]

2. The grade of high-carbon coal-tar pitch covered in these specifications is suitable for damp-proofing and waterproofing railroad bridges, tanks, retaining walls, culverts, dams, conduits, etc.

SAMPLING

Sampling.

3. The sampling shall be performed in accordance with the Standard Methods of Sampling Bituminous Materials (A.S.T.M. Designation: D 140) of the American Society for Testing Materials.[3]

PROPERTIES

Properties.

4. The coal-tar pitch shall be homogeneous and shall conform to the following requirements:

(*a*) Water..0.0 per cent
(*b*) Specific gravity at 25° C. (77° F.)............1.25 to 1.35
(*c*) Softening Point[4] (Cube-in-Water Method)........................130 to 155° F. (54.4 to 68.3° C.)

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-8 on Bituminous Waterproofing and Roofing Materials.

[2] Such coal-tar pitch is not intended to be heated above 350° F. (176.6° C.) during its application.

[3] 1936 Book of A.S.T.M. Standards, Part II, p. 1088.

[4] The Softening Point (Cube-in-Water Method) should have a range of not over 10° F. within the limits given in Section 4 (*c*).

(*d*) **Distillation Test:**

Total distillate, by weight, 0 to 300° C. (32 to 572° F.)	**not more than 10.0 per cent**
Residue, by weight	**not less than 90.0 "**

(*e*) Specific gravity at 38°/25° C. (100°/77° F.) of total distillate to 300° C. (572° F.)..not less than 1.03

(*f*) Ductility at 25° C. (77° F.) .... not less than 20 cm.

(*g*) Insoluble in carbon disulfide............. 22 to 37 per cent

METHODS OF TESTING

Methods of Testing.

5. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Percentage of Water:* Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (A.S.T.M. Designation: D 95).[1]

(*b*) *Specific Gravity:* Standard Method of Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements and Soft Tar Pitches (A.S.T.M. Designation: D 70).[2]

(*c*) *Softening Point:* Standard Method of Test for Softening Point of Tar Products (Cube-in-Water Method) (A.S.T.M. Designation: D 61).[3]

(*d*) *Distillation:* Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (A.S.T.M. Designation: D 20).[4]

(*e*) *Ductility:* Standard Method of Test for Ductility of Bituminous Materials (A.S.T.M. Designation: D 113).[5]

(*f*) *Insoluble in Carbon Disulfide:* Standard Method of Test for the Determination of Bitumen (A.S.T.M. Designation: D 4).[6]

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 997.

[2] *Ibid.*, p. 1110.

[3] *Ibid.*, p. 1103.

[4] *Ibid.*, p. 1053.

[5] *Ibid.*, p. 1058.

[6] *Ibid.*, p. 1041.

TENTATIVE SPECIFICATIONS
FOR
HIGH-CARBON COAL-TAR PITCH FOR USE IN DAMP-PROOFING AND WATERPROOFING BELOW GROUND LEVEL[1]

A.S.T.M. Designation: D 42 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED AS TENTATIVE, 1917; ADOPTED IN AMENDED FORM, 1925;
REVERTED TO TENTATIVE, 1936.

Scope. 1. These specifications cover high-carbon coal-tar pitch suitable for use as a mopping-coat in damp-proofing or as a plying-cement in the construction of a membrane system of waterproofing below ground level, under uniformly moderate temperature conditions both during the process of installation and during service.[2]

2. The grade of high-carbon coal-tar pitch covered by these specifications is suitable for damp-proofing and waterproofing foundations, tunnels, subways, etc.

SAMPLING

3. The sampling shall be performed in accordance with the Standard Methods of Sampling Bituminous Materials (A.S.T.M. Designation: D 140) of the American Society for Testing Materials.[3]

PROPERTIES

Properties. **4. The coal-tar pitch shall be homogeneous and shall conform to the following requirements:**

(*a*) Water.......................................0.0 per cent
(*b*) Specific gravity at 25° C. (77° F.)...........1.24 to 1.34
(*c*) Softening Point[4] (Cube-in-Water Method)..............
.......................110 to 140° F. (43.3 to 60.0° C.)

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-8 on Bituminous Waterproofing and Roofing Materials.

[2] Such coal-tar pitch is not intended to be heated above 300° F. (148.8° C.) during its application.

[3] 1936 Book of A.S.T.M. Standards, Part II, p. 1088.

[4] The Softening Point (Cube-in-Water Method) specified should have a range of not over 10° F. within the limits given in Section 4 (*c*).

(*d*) **Distillation Test:**

Total distillate, by weight, 0.0 to 300° C.
(32 to 572° F.)........................not more than 12.0 per cent
Residue, by weight.....................not less than 88.0 "

(*e*) Specific gravity at 38°/25° C. (100°/77° F.) of total distillate to 300° C. (572° F.)..........................not less than 1.03

(*f*) Ductility at 25° C. (77° F.)...........not less than 50 cm.

(*g*) Insoluble in carbon disulfide...............20 to 35 per cent

METHODS OF TESTING

Methods of Testing. 5. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Percentage of Water:* Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (A.S.T.M. Designation: D 95).[1]

(*b*) *Specific Gravity:* Standard Method of Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements and Soft Tar Pitches (A.S.T.M. Designation: D 70).[2]

(*c*) *Softening Point:* Standard Method of Test for Softening Point of Tar Products (Cube-in-Water Method) (A.S.T.M. Designation: D 61).[3]

(*d*) *Distillation:* Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (A.S.T.M. Designation: D 20).[4]

(*e*) *Ductility:* Standard Method of Test for Ductility of Bituminous Materials (A.S.T.M. Designation: D 113).[5]

(*f*) *Insoluble in Carbon Disulfide:* Standard Method of Test for the Determination of Bitumen (A.S.T.M. Designation: D 4).[6]

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 997.

[2] *Ibid.*, p. 1110.

[3] *Ibid.*, p. 1103.

[4] *Ibid.*, p. 1053.

[5] *Ibid.*, p. 1058.

[6] *Ibid.*, p. 1041.

TENTATIVE SPECIFICATIONS
FOR
CREOSOTE FOR PRIMING COAT WITH COAL-TAR PITCH IN DAMP-PROOFING AND WATERPROOFING BELOW AND ABOVE GROUND LEVEL[1]

A.S.T.M. Designation: D 43 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED AS TENTATIVE, 1917; ADOPTED IN AMENDED FORM, 1925;
REVERTED TO TENTATIVE, 1936.

Scope. 1. These specifications cover creosote primer for use, when specified, with coal-tar pitch in damp-proofing and waterproofing below or above ground level, for application to concrete and masonry surfaces.

SAMPLING

Sampling. 2. From each shipment or portion thereof representing creosote of the same kind, a number of packages shall be selected at random equivalent to the cube root of the total number of packages in the lot. If the cube root as calculated proves to be a fractional number, it shall be expressed as the next higher whole number. For convenience, the following table is given, showing the number of samples to be selected for shipments of various sizes:

PACKAGES IN SHIPMENT.	PACKAGES SELECTED.	PACKAGES IN SHIPMENT.	PACKAGES SELECTED.
2 to 8	2	217 to 343	7
9 to 27	3	344 to 512	8
28 to 64	4	513 to 729	9
65 to 125	5	730 to 1000	10
126 to 216	6	1001 to 1331	11

3. By means of a paddle, the contents of each package selected shall be thoroughly stirred so as to bring all portions thereof into uniform distribution. With an appropriate sampler, not less than 1 pt. of the creosote oil shall be immediately drawn out from the center of each package and transferred to a clean receptacle of suitable size, which in turn shall be kept tightly covered, prior and immediately after said samples are being introduced. After all the pint

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-8 on Bituminous Waterproofing and Roofing Materials.

samples have been added, the contents of the container shall be thoroughly agitated, whereupon 1 qt. of the mixture shall immediately be transferred to a clean quart can provided with a tightly fitting screw cap, which shall be immediately fastened in place. This sample shall be considered as representative of the shipment and shall be transmitted to the laboratory for examination, bearing a suitable tag or other means of identification.

PROPERTIES

Properties.

4. The creosote primer shall conform to the following requirements:

(*a*) Water........................not more than 2 per cent
(*b*) Consistency at 38° C. (100° F.)..............entirely fluid
(*c*) Specific gravity at 38°/25° C. (100°/77° F.) ....1.00 to 1.06
(*d*) Insoluble in benzol.............not more than 1 per cent
(*e*) Distillation Test:

Total distillate, by weight, under 200° C. (392° F.)...........................not more than 5 per cent
Total distillate, by weight, under 235° C. (455° F.).............not more than 50 nor less than 30 "
Residue, by weight, above 355° C. (671° F.).. not more than 15 "

(*f*) Specific gravity at 38°/25° C. (100°/77° F.) of the fraction distilling between 235 and 315° C. (455 and 599° F.)...........not less than 1.00
(*g*) Consistency at 25° C. (77° F.) of the residue........ soft

METHODS OF TESTING

Methods of Testing.

5. The properties enumerated in these specifications shall be determined in accordance with the Standard Methods of Sampling and Testing Creosote (A.S.T.M. Designation: D 38) of the American Society for Testing Materials.[1]

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 531.

TENTATIVE SPECIFICATIONS
FOR
PRIMER FOR USE WITH ASPHALT IN DAMP-PROOFING AND WATERPROOFING BELOW AND ABOVE GROUND LEVEL[1]

A.S.T.M. Designation: D 41 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED AS TENTATIVE, 1917; ADOPTED IN AMENDED FORM, 1925; REVISED, 1926; REVERTED TO TENTATIVE, 1936.

Scope. 1. These specifications cover asphaltic primer for use, when specified, with asphalt in damp-proofing and waterproofing below or above ground level, for application to concrete and masonry surfaces.

SAMPLING

Sampling. 2. From each shipment or portion thereof representing primer of the same kind, a number of packages shall be selected at random equivalent to the cube root of the total number of packages in the lot. If the cube root as calculated proves to be a fractional number, it shall be expressed as the next higher whole number. For convenience, the following table is given, showing the number of samples to be selected for shipments of various sizes:

PACKAGES IN SHIPMENT	PACKAGES SELECTED	PACKAGES IN SHIPMENT	PACKAGES SELECTED
2 to 8	2	217 to 343	7
9 to 27	3	344 to 512	8
28 to 64	4	513 to 729	9
65 to 125	5	730 to 1000	10
126 to 216	6	1001 to 1331	11

3. By means of a paddle, the contents of each package selected shall be thoroughly stirred so as to bring all portions thereof into uniform distribution. With an appropriate sampler, not less than 1 pt. of the primer shall be immediately drawn from the center of each package, and transferred to a clean receptacle of suitable size, which in turn shall be kept tightly covered, prior and immediately after said

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-8 on Bituminous Waterproofing and Roofing Materials.

samples are being introduced. After all the pint samples have been added, the contents of the container shall be thoroughly agitated, whereupon 1 qt. of the mixture shall immediately be transferred to a clean quart can provided with a tightly fitting screw cap, which shall be immediately fastened in place. This sample shall be considered as representative of the shipment and shall be transmitted to the laboratory for examination, bearing a suitable tag or other means of identification.

PROPERTIES

Asphaltic Base.

4. The asphaltic base used in preparing the primer shall meet the requirements specified in the Tentative Specifications for Asphalt for Use in Damp-proofing and Waterproofing Below Ground Level (A.S.T.M. Designation: D 40–36 T) of the American Society for Testing Materials.[1]

Solvent.

5. The solvent used in preparing the primer shall be a hydrocarbon distillate having an end point on distillation of not above 260° C. (500° F.), of which not more than 20 per cent shall distill under 120° C. (248° F.).

Primer.

6. The primer shall be free from water and shall conform to the following requirements:

(*a*) Sediment........................not more than 1 per cent
(*b*) Asphaltic base by weight................25 to 35 "

METHODS OF TESTING

Methods of Testing.

7. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Distillation:* Standard Method of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (A.S.T.M. Designation: D 86).[2]

(*b*) *Sediment:* Standard Method of Test for Water and Sediment in Petroleum Products, by Means of Centrifuge (A.S.T.M. Designation: D 96).[3]

(*c*) *Weight of Asphaltic Base Present:* Standard Method of Test for Steam Distillation of Bituminous Protective Coatings (A.S.T.M. Designation: D 255).[4]

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[1] See p. 894.

[2] 1936 Book of A.S.T.M. Standards, Part II, p. 870.

[3] *Ibid.*, p. 1001.

[4] *Ibid.*, p. 1150.

TENTATIVE SPECIFICATIONS

FOR

BLACK BIAS-CUT VARNISHED CLOTH TAPE USED FOR ELECTRICAL INSULATION[1]

A.S.T.M. Designation: D 373 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1933; REVISED, 1934, 1936.

Scope

1. These specifications cover black seamless and sewed-seam bias-cut varnished cloth tapes 7 to 12 mils in thickness to be used for insulating bus bars, joints and terminals of electric wires and cables, and other electrical apparatus connections.

NOTE.—Orders for material under these specifications shall include the following information:

The desired nominal thickness, width and length (Sections 7, 8 and 9);
Whether seamless or sewed-seam tapes are desired (Sections 4 and 5);
Type of surface, greasy or tacky (Section 10);
Type of packing, dry or oil (Sections 18, 19 and 20);
Number of rolls in package (Sections 19 and 20); and
Marking on package (Section 21).

MANUFACTURE

Cloth and Varnish

2. The cloth and the number of coats of varnish applied shall be such as to produce a product which will meet the requirements of these specifications.

Defects

3. In general, the tape shall be free from wrinkles, excessive pebbling, blisters, and other imperfections.

Splices

4. Splices are those joints made by the manufacturer of the untreated cloth. In the case of seamless bias-cut tapes, splices shall not occur more than once in each roll, except that rolls having a length of 6 yd. or less shall contain no splices.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-9 on Electrical Insulating Materials.

Seams

5. Seams are those joints made during or subsequent to the varnish treatment of the cloth. In the case of sewed-seam bias-cut tapes, seams shall not occur more than once in each 45 in. of length.

METHODS OF TESTING

Methods of Testing

6. (*a*) Varnished cloth tape shall be sampled, conditioned and tested in accordance with the Tentative Methods of Testing Varnished Cloths and Varnished Cloth Tapes Used in Electrical Insulation (A.S.T.M. Designation: D 295 - 36 T) of the American Society for Testing Materials.[1]

(*b*) All specimens taken from a single roll shall be numbered or marked so that failures can be identified with the roll.

DIMENSIONS AND PERMISSIBLE VARIATIONS

Thickness

7. The nominal thickness shall be specified in the purchase order. The average thickness shall be determined from the ten measurements taken on a specimen before testing in accordance with Section 15. The average thickness shall not vary more than ±0.001 in. from the specified nominal thickness, and no individual measurement shall vary more than +0.002 or −0.001 in. for tapes from 5 to 9 mils in thickness, nor more than ±0.003 in. for tapes 10 to 12 mils in thickness, from the specified nominal thickness.

Width

8. The nominal width shall be specified in the purchase order. Individual measurements on all the samples selected under Section 6 shall not vary more than $\pm\frac{1}{32}$ in. from the specified nominal width for tapes 1 in. or less in width, nor more than $\pm\frac{1}{16}$ in. for tapes over 1 in. in width.

Length

9. The nominal length or yards per roll shall be specified in the purchase order. The measured lengths of individual rolls selected under Section 6 shall be not less than that specified.

PHYSICAL PROPERTIES AND TESTS

Surface

10. Tapes are roughly divisible into two classes: "greasy" and "tacky." Greasy tapes shall have the property of sliding freely, one layer upon another, when moved easily between two fingers.

Flexibility

11. The varnish coating shall be flexible and shall not crack when the tape is doubled upon itself and creased between the thumb and

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[1] See p. 1031.

index finger. Care shall be taken not to bring the finger nails into contact with the tape surfaces while making the crease.

Tensile Breaking Strength

12. (*a*) The tensile breaking strength requirement varies with the nominal thickness of the tape. Let t represent the nominal thickness in mils; then, the average tensile breaking strength of the specimens should be not less than $35 + (t-7)$ lb. per inch of width. If the first specimen from a roll does not conform to this requirement, tests of two additional specimens from the same roll shall be made. Then the average of the three tests shall conform to the above requirements. The tensile breaking strength of any of the tests made shall be not less than $29 + (t-7)$ lb. per inch of width.

(*b*) The tensile breaking strength of the "jointed selvages," in the case of seamless bias-cut tapes, shall not be less than 80 per cent of the values specified in Paragraph (*a*).

(*c*) The tensile breaking strength of the "seams," in the case of sewed-seam bias-cut tapes, shall not be less than 60 per cent of the values specified in Paragraph (*a*).

Elongation

13. (*a*) For tapes of nominal width not less than 0.5 in., the elongation of one specimen from each of the selected rolls shall be measured at a temperature T between 20 and 30 C. and shall be not less than that specified in the following table:

NOMINAL THICKNESS	LOAD, LB. PER INCH OF TAPE WIDTH	ELONGATION, PER CENT
7 mils	5	$1.7 + (T-20) \times 0.1$
Over 7 mils	6	$1.7 + (T-20) \times 0.1$

(*b*) The specimens tested for elongation shall be used for electrical tests as described in Section 16.

Resistance to Oil

14. (*a*) One specimen from each of the selected rolls shall be subjected to test for resistance to oil described in the test methods referred to in Section 6. The oil used shall be an insulating oil having a flash point of not less than 135 C. (275 F.), as determined by the Cleveland open cup in accordance with the Standard Method of Test for Flash and Fire Points by Means of Open Cup (A.S.T.M. Designation: D 92) of the American Society for Testing Materials.[1] The varnished film shall show no evidence of disintegration in the oil nor flake either in the oil or on the blotter used in the test.

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 892.

(*b*) The specimens tested for resistance to oil shall be used for electrical tests as described in Section 17.

Dielectric Strength, as Received

15. (*a*) Ten punctures shall be made on one specimen from each roll as received. The dielectric strength values are the puncture values in volts divided by the average of the ten thickness readings on the specimens in mils. The average of the ten dielectric strength values for each roll as received, shall conform to the requirements shown in Table I. The dielectric strength values when analyzed to determine the uniformity of the material shall conform to the requirements of Paragraphs (*b*) and (*c*).

TABLE I.—DIELECTRIC STRENGTH REQUIREMENTS FOR VARNISHED CLOTH TAPE.

	DIELECTRIC STRENGTH, MINIMUM AVERAGE VOLTS PER MIL		
NOMINAL THICKNESS	AS RECEIVED	AFTER ELONGATION	AFTER HOT OIL
Over 10 mils..............	1100	1000	1100
9 and 10 mils, incl..........	1000	900	1000
Under 9 mils..............	900	800	900

(*b*) *Uniformity Within the Roll.*—The deviation factor for each roll in each shipment shall be not more than 0.08 when calculated from the following formula:

$$\text{Deviation factor of roll} = \frac{h - l}{h + l}$$

where h = the average of the five highest dielectric strength values of the roll, in volts per mil; and

l = the average of the five lowest dielectric strength values of the roll, in volts per mil.

(*c*) *Uniformity of the Shipment.*—The deviation factor for each roll in each shipment shall be not more than 0.07 when calculated from the following formula:

$$\text{Deviation factor of shipment} = \frac{a - l}{a + l}$$

where a = the average dielectric strength of the entire shipment, in volts per mil; and

l = the average of the five lowest dielectric strength values of the roll, in volts per mil.

Dielectric Strength, After Elongation

16. Five punctures shall be made inside the gage length on each specimen after the elongation test specified in Section 13. The average of the five dielectric strength values for each roll shall conform to the requirements shown in Table I.

Dielectric Strength, After Hot Oil

17. Five punctures shall be made on each specimen after the test for resistance to oil specified in Section 14. The average of the five dielectric strength values for each roll shall conform to the requirements shown in Table I.

PACKING AND MARKING

Packing

18. The purchaser shall specify whether tape is to be supplied dry or immersed in oil.

Dry Packing

19. In the case of dry tape, the purchaser shall specify the number of rolls per package and whether each roll shall be dipped or whether each package shall be dipped in a moisture-resistant wax or neither or both. The wrapping shall be secure and shall protect the contents.

Packing in Oil

20. Oil-immersed tape shall be supplied in suitable oil-tight cans with easily removable lids. The purchaser shall specify the number, width and length of rolls to be supplied in each can. The type of oil used for packing shall be subject to the approval of the purchaser.

Marking

21. The purchaser shall specify the marking desired on each package or can; unless the marking is definitely specified, the package shall conform with the usual trade customs.

INSPECTION AND REJECTION

Inspection and Testing

22. The material shall be inspected and tested within three weeks of its receipt by the purchaser.

Rejection

23. (*a*) The purchaser reserves the right to reject any part of the shipment that does not conform to the requirements for packing and marking as specified in Sections 19, 20 and 21.

(*b*) The failure of a sample roll to conform to the requirements of one or more of the sections enumerated under Paragraphs (*c*) and (*d*) shall be counted as only one roll failure.

(*c*) The failure of 35 per cent or more of the sampled rolls to conform to the requirements of Sections 3, 4, 5, 7, 8, 9, 10 and 11 shall constitute cause for rejection of the entire shipment without further tests.

(*d*) The failure of 50 per cent or more of the sampled rolls to conform to the requirements of Sections 12, 13, 14, 15, 16 and 17 shall constitute cause for rejection of the entire shipment.

NOTE.—The following illustrates a convenient method of recording failures of sampled rolls:

ROLL NO.	FAILURES UNDER SECTIONS								ROLL FAILURES
	3	4	5	7	8	9	10	11	
1				X					X
2				X	X				X
3									
4									
5									
6					X	X		X	X
7									
8									
9									
10									
Total rolls sampled = 10									Total failures = 3 rolls

Thirty per cent of the rolls failed; therefore, this shipment passes Paragraph (*c*).

Claims

24. Rejection claims shall be made to the seller in writing within four weeks of receipt of material by the purchaser. The results of tests made by the purchaser on which rejection is based shall be furnished to the seller, who shall, within one week of receipt of all such claims, either agree to satisfy the claim or send a representative to the plant of the purchaser to resample the shipment. Samples so selected shall be sealed and submitted to an umpire, mutually agreeable to the purchaser and seller, whose decision should be final.

Settlement of Claims

25. The expense of the umpire tests shall be paid by the loser. In the case of rejection being established, the seller shall pay the freight both ways on the rejected material.

TENTATIVE METHODS OF TESTING SHEET, TAPE, AND MOLDED INSULATING MATERIALS FOR DIELECTRIC STRENGTH[1]

A.S.T.M. Designation: D 149 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1922; Revised, 1923, 1924, 1926, 1927, 1930, 1931, 1932, 1933, 1934, 1936.[2]

Scope

1. (*a*) These methods are intended to determine the dielectric strength of sheet, tape and molded insulating materials except rubber insulating tape which should be tested in accordance with the Tentative Specifications and Tests for Rubber Insulating Tape (A.S.T.M. Designation: D 119 – 35 T) of the American Society for Testing Materials,[3] and friction tape for electrical purposes which should be tested in accordance with the Tentative Specifications and Tests for Friction Tape for General Use for Electrical Purposes (A.S.T.M. Designation: D 69 – 36 T) of the American Society for Testing Materials.[4]

Types of Tests

(*b*) Since the dielectric strength of sheet, tape, and molded materials is dependent upon the time of application of the electrical tension, three tests differing in time duration are included as follows:

A. Short-Time Dielectric Strength Test.
B. One-Minute Step-by-Step Dielectric Strength Test.
C. Endurance Dielectric Strength Test.

Note.—Method C shows the relative dielectric strength of different flexible sheet, tape and molded insulating materials at high temperature when subjected to electrical tensions for relatively long periods.

Sheet Materials

(*c*) Sheet materials are divisible into two general classes: (*1*) thin, flexible materials, easily bent or wrapped around conductors, and (*2*) stiff sheet and plate materials, slightly flexible or rigid.

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-9 on Electrical Insulating Materials.

[2] Latest revision accepted by Committee E-10 on Standards, August 26, 1936.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1110 (1935); also 1936 Book of A.S.T.M. Tentative Standards, p. 1054.

[4] See p. 1059.

(*1*) Tests on thin, flexible materials at room temperature shall be made in accordance with Method *A* Short-Time Dielectric Strength Tests as specified in Sections 3 to 12; with Method *B* One-Minute Step-by-Step Dielectric Strength Test as specified in Sections 13 to 21, or with Method *C* Endurance Dielectric Strength Test as specified in Sections 22 to 26.

(*2*) Tests on stiff sheet and plate materials at room temperature shall be made in accordance with the special instructions covered under Dielectric Strength Tests on Stiff Sheet and Plate Materials in Sections 27 to 31.

Molded Materials

(*d*) Tests on molded materials at room temperature shall be made in accordance with the special instructions prescribed for Dielectric Strength Tests on Molded Materials in Sections 32 to 36.

APPARATUS

High-Voltage Transformer

2. (*a*) Any well-designed, high-voltage transformer connected to an alternating current supply, having as nearly a true sine wave as possible, may be used. The transformer and the source of supply of energy shall be not less than 2 kva. for voltages of 50,000 v. or less, and not less than 5 kva. for voltages above 50,000 v. The frequency shall not exceed 100 cycles per second.

(*b*) Regulation shall be so controlled that the high-tension testing voltage taken from the secondary of the testing transformer can be raised gradually from any point and in no case more than 500 v. at a step. The control may be made by generator field regulation, with an induction regulator, or with a variable ratio auto transformer, Any method of regulating the voltage is satisfactory which does not distort the wave more than 10 per cent from a sinusoidal shape.

(*c*) The voltage may be measured by any approved method which gives root-mean-square values, preferably by means of a voltmeter connected to a special voltmeter coil in the high-tension winding of the testing transformer, or to a separate step-down instrument potential transformer. A voltmeter on the low-tension side of the transformer is satisfactory, if the ratio of transformation does not change under any test condition. An electrostatic voltmeter properly calibrated in the high-tension circuit is also satisfactory. A spark gap may be used to check the readings at very high potentials.

(*d*) Some protection is desirable in the high-tension circuit of testing transformers where the potential is 25,000 v. or over, to prevent dangerous surges and limit the current when the test specimen is punctured. It is, however, desirable to have as much energy available as possible when puncture occurs. If impedance in the form of choke coils is used in series with the high-tension terminals, it should not be greater than that which will limit the high-tension current to double the normal rated current of the testing transformer.

When a spark gap is used, a non-inductive resistance of about one ohm per volt should be inserted in series with one terminal of the spark gap, to damp high-frequency oscillations at the time of breakdown and limit the current flow. This resistance shall be as near the gap as possible. If the test is made with one side grounded, this resistance shall be on the ungrounded side of the circuit, and if neither side is grounded, the resistance shall be inserted one-half on each side of the spark gap. Water tube resistors are preferable to carbon for this purpose, as carbon resistance may be materially decreased by the passage of current.

(*e*) The apparatus used and the method of measuring the voltage shall meet the requirements of the Standards of the American Institute of Electrical Engineers.

A. Short-Time Dielectric Strength Test

Electrodes

3. The electrodes shall be of brass or copper with flat polished contact surfaces, as follows:

(*a*) For sheet and plate materials the electrodes shall be cylinders 2 in. (50.8 mm.) in diameter and 1 in. (25.4 mm.) in length with the edges rounded to a radius of $\frac{1}{4}$ in. (6.35 mm.).

(*b*) For tapes the electrodes shall be cylindrical rods $\frac{1}{4}$ in. (6.35 mm.) in diameter with edges rounded to a radius of $\frac{1}{32}$ in. (0.8 mm.) and the upper movable one shall weigh 0.1 lb. ± 0.005 lb. (45.4 g. ± 2.3 g.).

(*c*) For molded materials the electrodes shall be cylinders 1 in. (25.4 mm.) in diameter and 1 in. (25.4 mm.) in length with the edges rounded to a radius of $\frac{1}{8}$ in. (3.18 mm.).

NOTE.—Since the apparent dielectric strength of a material varies with the area of the electrodes used in making the test, results obtained with these different electrodes are not comparable.

TEST SPECIMENS

Test Specimens

4. (*a*) The test specimens may be of any convenient size, but the total area of the specimens of one sample of material shall be sufficient to permit making at least ten satisfactory tests.

(*b*) The specimens shall be representative of the material to be tested, care being taken to select material which is free from abnormal defects such as blisters, wrinkles, cracks, etc.

PROCEDURE

Surrounding Medium

5. The tests shall be made in air with the specimen at room temperature.

Condition of Electrodes

6. The testing electrodes shall be kept clean and polished.

Position of Electrodes and Specimen

7. (*a*) The electrodes shall be self-aligning, and shall be placed exactly opposite one another with the specimen in a horizontal plane between them.

(*b*) The electrodes shall be so mounted as to preclude any surface burning of the tape whatever and to prevent flashovers. If flashovers occur either over the edge of the tape or from the upper electrode to an adjacent lower electrode, or if the punctures in the tape are accompanied by a burning or charring of the surface of the tape, all the voltage readings obtained in making the test will not be reliable and shall be discarded and a new specimen tested.

8. The edges of tapes shall be clamped between blocks of insulating material under a pressure of approximately 100 lb. per sq. in. to prevent flashover occurring before puncture.

NOTE.—In the Appendix two devices are shown which have been found satisfactory for use in testing tapes.

Application of Voltage

9. Starting at zero, the voltage shall be increased uniformly to breakdown at a rate of 0.5 kv. per sec., except that if breakdown occurs at this rate in less than 40 sec., the rate shall be decreased so that breakdown will occur in not less than 40 sec. If the material fails at less than 5 kv., the minimum time shall be reduced from 40 sec. to 20 sec.

Number of Tests

10. Unless otherwise specified, ten tests shall be made and the average of these ten puncturing voltages shall be taken.

Thickness

11. (*a*) The number of thickness readings on the specimen shall be at least equal to the number of punctures made in accordance with Section 10.

NOTE.—The micrometers and mode of operation specified in the Tentative Methods of Test for Thickness of Solid Electrical Insulation (A.S.T.M. Designation: D 374 - 36 T) of the American Society for Testing Materials[1] are suitable for this purpose.

(*b*) In the cases of sheet material and molded material, the thickness shall be measured near the point of puncture.

(*c*) In the case of tapes, Method B[1] of the Tentative Methods D 374 - 36 T shall be used. The readings shall be distributed along the center line of the specimen in such manner as to represent closely the thickness at the point of puncture. The average of these readings shall be the thickness used in calculating dielectric strength.

Report

12. Unless otherwise specified, the report shall include the following:

(*a*) The thickness of the specimen as determined in Section 11;
(*b*) Total volts at each puncture;
(*c*) Volts per mil of thickness for each puncture;
(*d*) The average, maximum, and minimum volts per mil of thickness for each sample;
(*e*) The room temperature;
(*f*) The relative humidity, in per cent; and
(*g*) The duration of the test.

B. One-Minute Step-by-Step Dielectric Strength Test

TEST SPECIMENS

Test Specimens

13. The test specimens shall be as specified in Section 4.

PROCEDURE

Surrounding Medium

14. The tests shall be made in air with the specimen at room temperature.

Condition of Electrodes

15. The testing electrodes shall be kept clean and polished.

Position of Electrodes and Specimen

16. The electrodes shall be self-aligning, and shall be placed exactly opposite one another with the specimen in a horizontal plane between them.

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[1] See p. 1026.

17. The edges of tapes shall be clamped between blocks of insulating material under a pressure of approximately 100 lb. per sq. in. to prevent flashover occurring before puncture.

NOTE.—In the Appendix are shown two different devices which have been found satisfactory for use in testing tapes.

Application of Voltage

18. An initial voltage shall be applied equal to 40 per cent of the breakdown voltage in the short-time test, adjusted as shown in the following table. The voltage shall then be increased in increments as indicated in the table, up to failure, being held at each step for 1 min. The change from each step to the next higher shall be made within 10 sec.

BREAKDOWN KILOVOLTS BY SHORT-TIME METHOD	ADJUST 40 PER CENT OF BREAKDOWN VOLTAGE TO NEAREST	INCREMENT OF INCREASE
12.5 kv. or less	0.5 kv.	0.5 kv.
over 12.5 to 25 kv., inclusive	1.0 kv.	1.0 kv.
over 25 to 50 kv., inclusive	2.5 kv.	2.5 kv.
over 50 to 100 kv., inclusive	5.0 kv.	5.0 kv.
over 100 kv	10.0 kv.	10.0 kv.

NOTE.—*Example:*

Breakdown voltage by short-time method = 41 kv.
40 per cent of breakdown voltage = 16.4 kv.
Initial voltage obtained by adjusting 40 per cent of breakdown voltage to nearest 2.5 kv. = 17.5 kv.
Voltage will be increased in increments of 2.5 kv.
Therefore, second step = 20.0 kv., etc.

Number of Tests

19. Five tests shall be made and the average of these five puncturing voltages shall be taken.

Thickness

20. The thickness of the specimen shall be measured in accordance with Section 11.

Report

21. Unless otherwise specified, the report shall include the following:

(*a*) The thickness of the specimen as determined in Section 11;
(*b*) Total volts at each puncture;
(*c*) Volts per mil of thickness for each puncture;
(*d*) The average, maximum, and minimum volts per mil of thickness for each sample;
(*e*) The room temperature;

(*f*) The relative humidity, in per cent;
(*g*) The duration of the test; and
(*h*) The value of the initially applied voltage and the value of the voltage at each step.

C. Endurance Dielectric Strength Test

Test Specimen

22. (*a*) The specimens shall be made by wrapping the material, in tape form with one-quarter lap, one-half lap, butt jointed or as sheets on brass tubes. The tubes shall be, for sheets and for tape up to 1½ in. in width, about 36 in. in length and 1 in. in outside diameter. For tapes wider than 1½ in., the tubes shall be 2 in. in outside diameter. The sample shall be built up to the desired thickness, simulating practical conditions, winding all layers of tape in the same direction.

(*b*) A smooth layer of metal foil shall then be wrapped over the insulation for a distance of 24 in., leaving 6 in. of insulation uncovered at each end of the tube. The metal foil shall be bound in place with a wrapping of adhesive tape which shall extend the full length of the tube in order to protect the insulation at the end from corona discharge.

(*c*) A thermocouple shall be applied to the metal foil near the center of the tube and held in place by the adhesive tape.

PROCEDURE

Position of Specimen

23. The specimen shall be mounted in an oven and a temperature of 100 C. (212 F.) maintained during the test. Provision shall be made for so mounting the specimen that the tube may be connected to the high voltage side of the circuit with the metal foil sheath and thermocouple connected to ground.

Application of Voltage

24. A voltage equal to 10 per cent of the breakdown voltage (to the nearest kilovolt) obtained in the short-time test (Method *A*) shall be applied and maintained for 30 min. The voltage shall then be increased by steps of 20 per cent of the initial value until puncture occurs, the voltage being held at each step for 30 min.

Temperature Readings

25. The temperature of the sample as indicated by the thermocouple shall be observed at intervals during the test and recorded at the end of each 30-min. period. It will be found that the temperature rises gradually until just before breakdown when the temperature increases rapidly. During this latter period, temperature readings shall be recorded at frequent intervals.

Report

26. The results shall be plotted using time, expressed in hours, as abscissas, and temperature, in degrees Centigrade, as ordinates. In addition to time as abscissas, the values of applied kilovolts shall be indicated since the value of kilovolts increases uniformly with time. The significant values to be taken from the curve and reported are:

(*a*) Duration of test;
(*b*) Breakdown voltage;
(*c*) Temperature of specimen at breakdown; and
(*d*) Rate of temperature rise during test.

The report shall also include a description of the specimen and its preparation, the thickness of the insulation and the number of layers of insulation.

Dielectric Strength Tests on Stiff Sheet and Plate Materials:

27. For testing stiff sheet and plate materials the procedure described in Method *A*, Short-Time Tests, Sections 2 to 12, and Method *B*, Step-by-Step Test, Sections 13 to 21, shall be modified in accordance with Sections 28 to 31.

Surrounding Medium

28. All tests shall be made under oil maintained at normal room temperature.

Conditioning

29. In the case of materials known to be affected by humidity, conditioning prior to dielectric strength test shall be carried out in accordance with the material specification applying to the material to be tested.

Position of Electrodes and Specimen

30. Tests may be transverse or parallel to the flat sides, or both, depending upon whether the stress on the material when in use is to be transverse or parallel to the flat sides, or both.

(*a*) Transverse tests shall be made between the standard 2-in. electrodes (Section 3 (*a*)).

NOTE.—Surface creepage and flashover at the higher voltages may be prevented by pouring around the electrodes any high-grade insulating compound which will form a good bond with the material and with the electrodes. Sealing wax and phenolic resin varnish have been successfully used under certain conditions. In applying this protective compound, care must be taken to prevent voids under the edges of the electrodes.

(*b*) For tests parallel to the flat sides, the material shall be cut into sections 2 in. square. Holes shall be drilled into opposite edges of each section so as to line up with each other, the inner ends of the holes being ½ in. apart. Metal electrodes shall be used, the ends of which exactly fit the ends of the holes. Thus, in effect, the material is tested edgewise in a modified needle gap. The diameter of hole should be approximately one-fourth the thickness of the specimen. For very thin specimens it may be necessary to use a larger ratio of drill size. Results shall be expressed in total kilovolts breakdown.

Number of Tests

31. For the Short-Time Method five tests shall be sufficient, and for the Step-by-Step Method, three tests.

Dielectric Strength Tests on Molded Materials:

32. For testing molded materials the procedure described in Method *A*, Short-Time Tests, Sections 3 to 12, and Method *B*, Step-by-Step Test, Sections 13 to 21, shall be modified in accordance with Sections 33 to 36.

Surrounding Medium

33. It is recommended that all tests on hot-molded materials be made under oil and tests on cold-molded materials in air.

Test Specimen

34. (*a*) The test specimen shall be molded in the form of a disk 4 in. (10.16 cm.) in diameter which shall be ⅛ in. (3.18 mm.) in thickness for hot-molded materials and ¼ in. (6.35 mm.) in thickness for cold-molded materials.

NOTE.—To permit the use of one mold for all molding compounds the following variations in dimensions of the test specimen will be permissible:

For hot-molded compounds........................	± 5 per cent
For cold-molded compounds.......................	± 10 per cent

Position of Electrodes

(*b*) Tests shall be made between the standard 1-in. electrodes (Section 3 (*c*)) located at the center of the specimen.

Number of Tests

35. For the Short-Time Method five tests shall be sufficient, and for the Step-by-Step Method, three tests.

Tests After Water Immersion

36. Three specimens shall be punctured after they have had the rim immersed in melted paraffin for a depth of 1 in. (25.4 mm.) and

have been entirely immersed in water for 48 hr. at normal room temperature of about 20 C. (68 F.). The surface of the specimen shall be wiped off with a dry cloth to remove all trace of excessive surface moisture and the puncture tests made immediately.

Tests at Different Temperatures:

37. Where the test materials are to be used at other than room temperature, their dielectric strength characteristic should be ascertained over the operating range of temperature.

Apparatus

38. Temperature control shall be obtained by the use of an air oven (or refrigerator) in the case of thin and cold-molded materials, or by the use of an oil bath, in the case of stiff sheet and plate, and hot-molded materials.

(*a*) The air oven should be provided with some means of circulating the air, so that approximately constant temperature is maintained around the test specimen, and with a thermometer or thermocouple for measuring the temperature as near the point of test as practicable. Any well-designed oven of sufficient size to hold the test equipment is satisfactory for this purpose.

(*b*) The oil bath should be provided with some means for circulating the oil, so that the temperature is substantially uniform around the test specimens, and with a thermometer or thermocouple for measuring the temperature as near the point of test as practicable.

Procedure

39. (*a*) The test material shall be subjected to the test temperature, before voltage is applied, for a period in minutes equal to hall the thickness of the specimen in mils, except molded materials, which shall be heated for 30 min.

(*b*) The tests shall cover the operating range of temperature to which the test material is to be subjected. Where this range is considerable, tests should be made at not less than four points, so that a curve of dielectric strength (volts per mil) against temperature may be plotted. These points should include the maximum and minimum operating temperatures. The number of tests at each temperature shall be as specified in Sections 10 and 31.

APPENDIX

Multiple Form of Tape Tester for Insulating Tapes:

Figure A1 shows the multiple electrode form of tape tester.[1] In this type, a strip of tape is held under pressure between rubber washers encircling the electrodes.

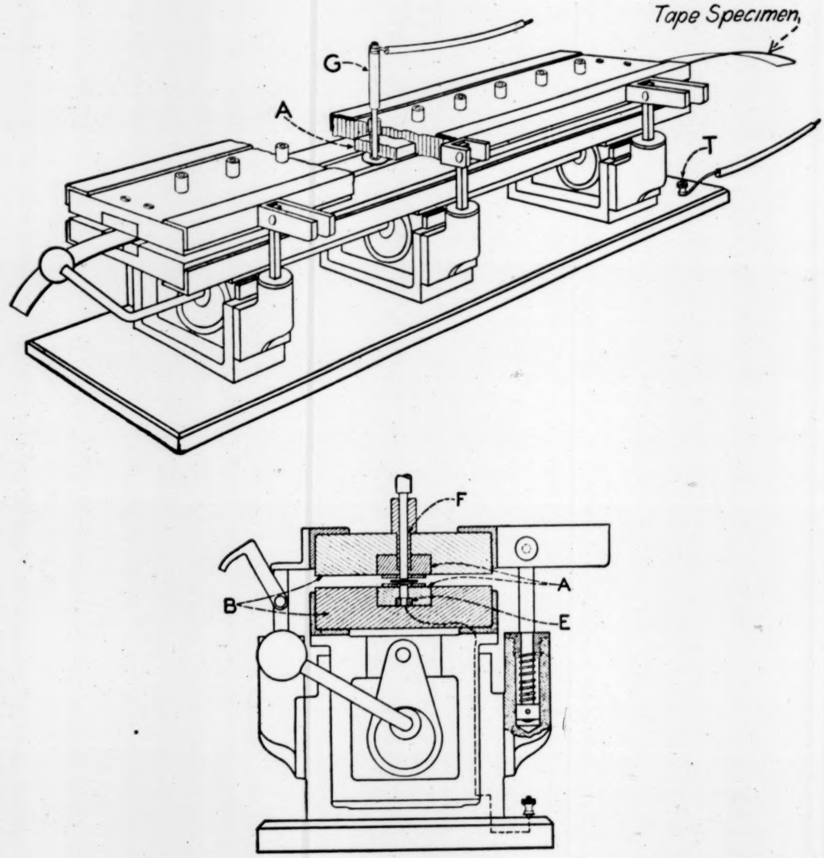

FIG. A1.—Multiple Electrode Tester for Dielectric Strength Test on Insulating Tape.

The washers, having center holes not smaller than $\frac{3}{8}$ in. in diameter, are cemented to two insulating blocks, *A*, which in turn are fastened to two rigid main blocks, *B*. Upper block, *B*, is hinged along one side and fitted with catches along the other to lock the two blocks together. A handle, operating cams through a common shaft, forces lower block, *B*, upward against upper block, *B*, the latter restrained by a set of springs along each side.

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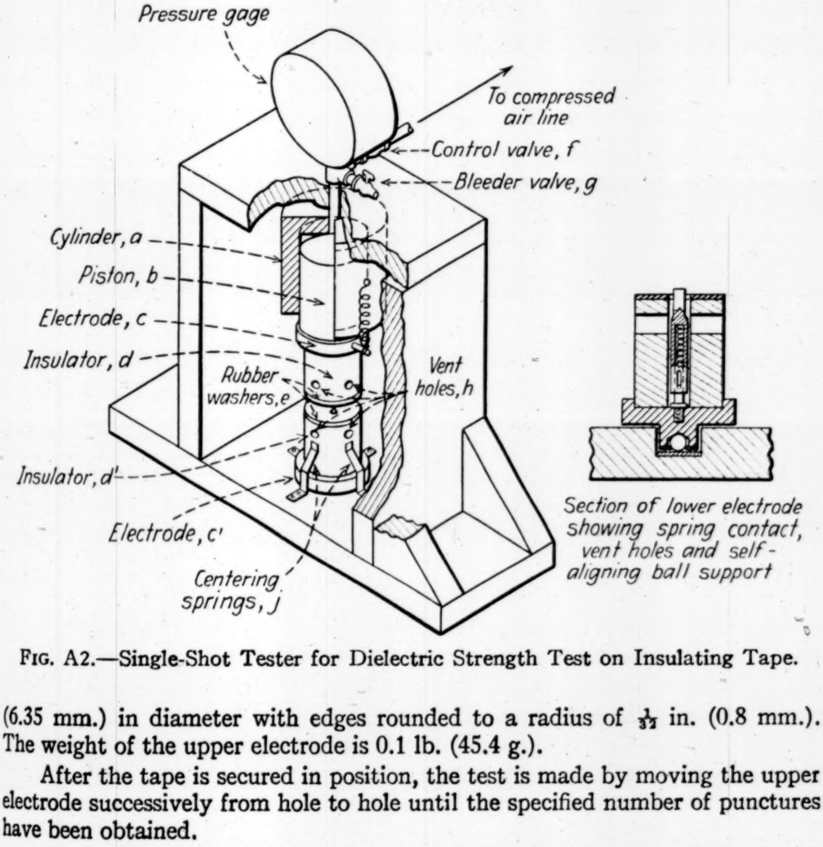
[1] A detailed drawing of the tape tester may be obtained from Mr. E. J. Rutan, Secretary of Committee D-9 on Electrical Insulating Materials, New York Edison Co., 92 Vandam St., New York City.

NOTE.—Satisfactory washers 1 in. square or $1\frac{1}{8}$ in. in diameter have been made of sheet rubber about 0.10 in. in thickness. The "hardness" of the rubber was such that when 10 washers were stacked, a weight of 15 lb. compressed the stack about 10 per cent of its original height.

There are ten lower electrodes which are fixed to a common bus bar, *E*. The upper electrode, *G*, is movable and may be inserted into any of the bushed holes, *F*, which serve to align the upper electrode with the corresponding lower electrode. Voltage is applied between the upper and lower electrodes by direct connection to the upper electrode and by connection to the common bus bar through terminal, *T*. The electrodes are cylindrical brass rods $\frac{1}{4}$ in. (6.35 mm.) in diameter with edges rounded to a radius of $\frac{1}{32}$ in. (0.8 mm.). The weight of the upper electrode is 0.1 lb. (45.4 g.).


Pressure gage
To compressed air line
Control valve, f
Bleeder valve, g
Cylinder, a
Piston, b
Electrode, c
Insulator, d
Rubber washers, e
Vent holes, h
Insulator, d'
Electrode, c'
Centering springs, j

Section of lower electrode showing spring contact, vent holes and self-aligning ball support

FIG. A2.—Single-Shot Tester for Dielectric Strength Test on Insulating Tape.

After the tape is secured in position, the test is made by moving the upper electrode successively from hole to hole until the specified number of punctures have been obtained.

As carbon is formed during tests, the successful operation of the device depends upon keeping the parts clean. When cleaning the electrodes, care should be taken not to change their form. The rubber washers may require replacement from time to time.

Single-Shot Tester for Insulating Tapes:

In the single-shot tester illustrated in Fig. A2 the tape is also held under pressure between rubber washers while the voltage is applied, but in this device pressure is supplied by compressed air operating on a piston, *b*, in a cylinder, *a*. The piston is connected to the upper electrode, *c*. The lower electrode, *c*′, is mounted on the insulated base. The electrodes terminate in ¼-in. brass rods having flat ends with edges rounded to a radius of $\frac{1}{32}$ in. These electrode rods move against light springs. This insures a positive contact between electrode and tape. The electrode rods are surrounded by insulating blocks, *d* and *d*′, having vent holes, *h*, for the dissipation of the gases generated by breakdown. These insulating blocks are faced with soft rubber washers, *e*, which can be detached and replaced as necessary.

The lower electrode assembly is lined up with the upper electrode assembly by centering springs, *j*, the position of which is adjustable. This lower assembly is also free to rock very slightly on a single ball support. This insures perfect contact and equalization of pressure when the electrode assemblies come together.

The upper electrode assembly is normally held clear of the lower assembly by two small springs so that tape may be readily inserted or withdrawn or moved to a new position of test. The piston, *b*, is smooth, without rings, and permits just enough leakage of air so that the pressure may be quickly adjusted and readily held at any desired value below the maximum available.

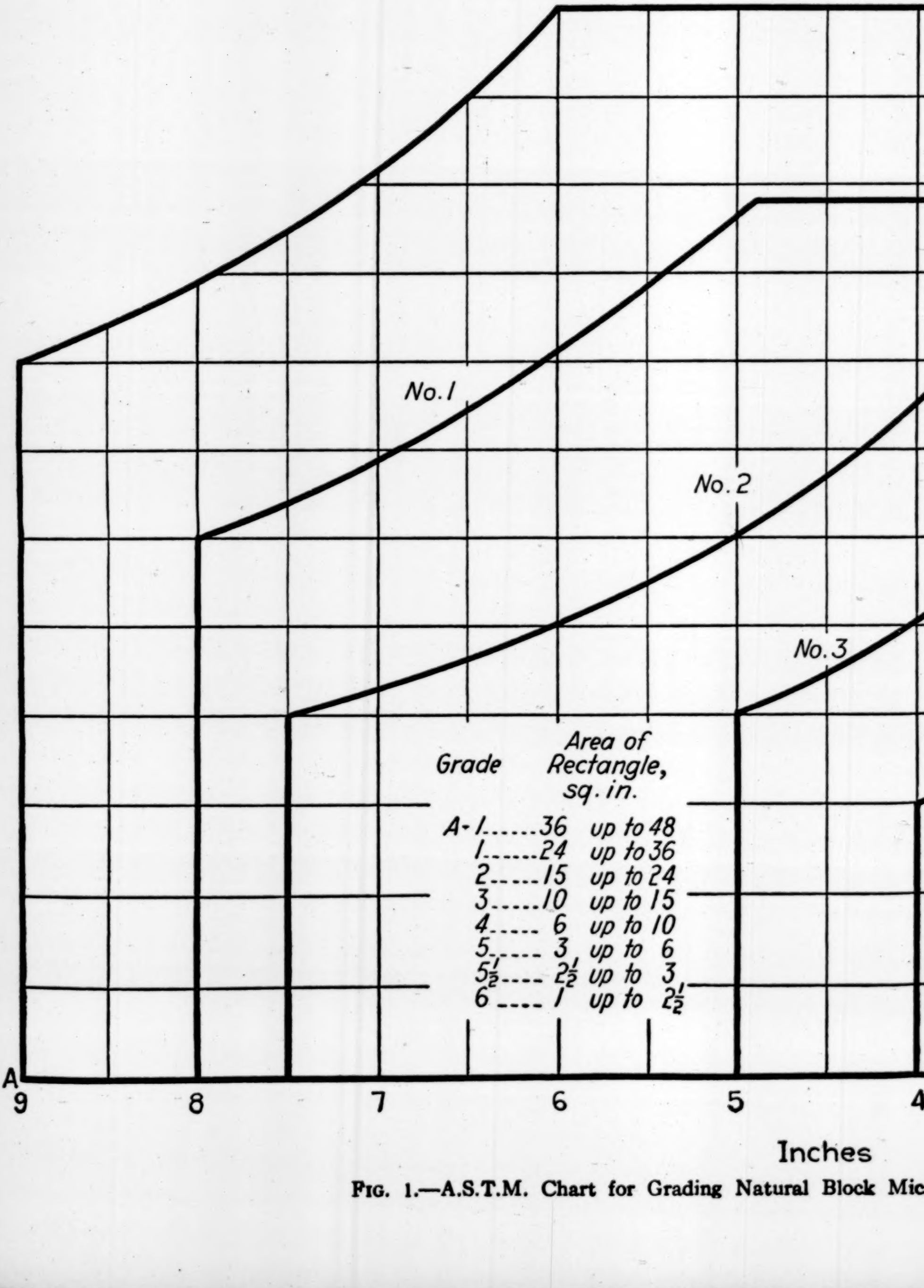
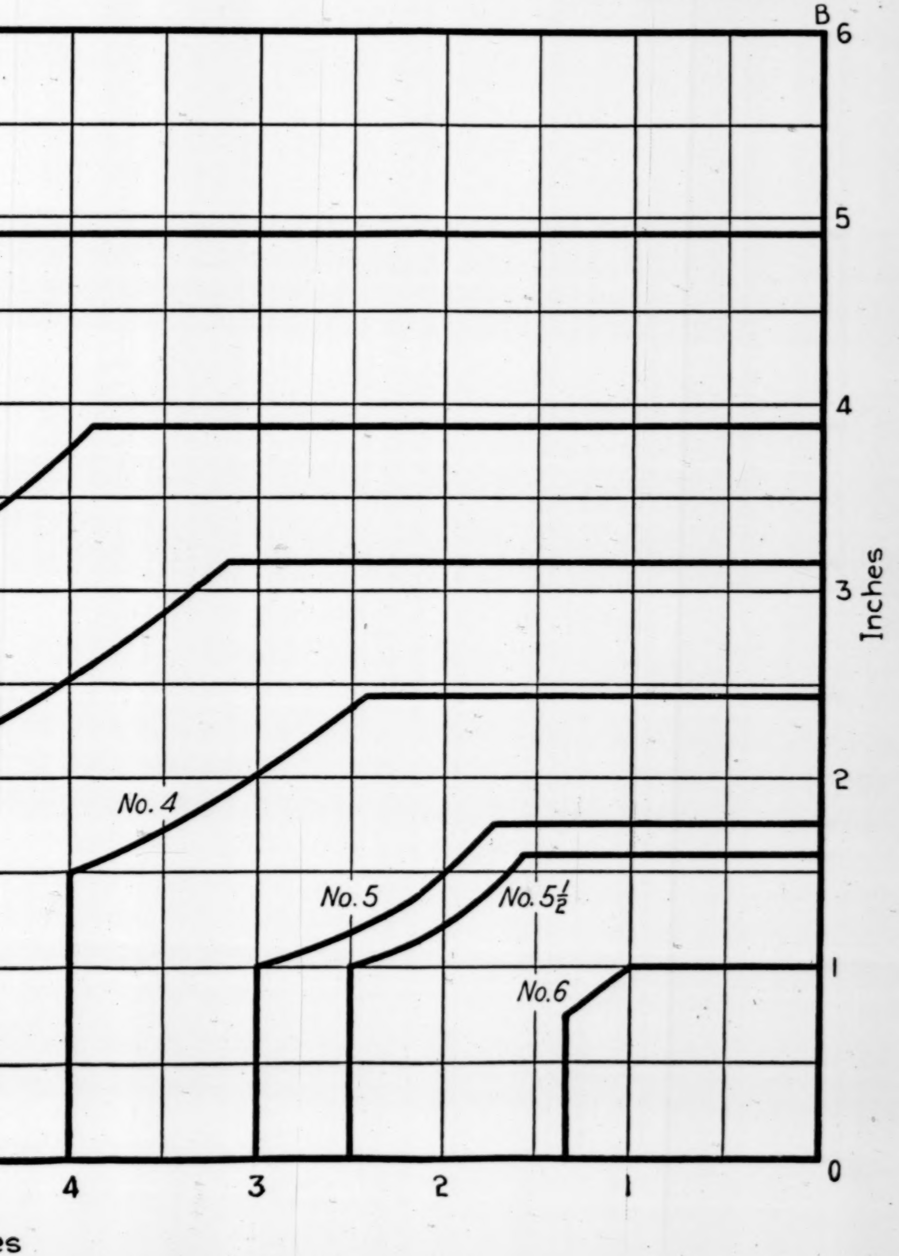


Fig. 1.—A.S.T.M. Chart for Grading Natural Block Mic

PLATE III.
PROCEEDINGS, AM. SOC. TESTING MATS.
VOL. 36, PART I

TENTATIVE METHODS OF TEST FOR
GRADING NATURAL MICA
A.S.T.M. DESIGNATION: D 351 - 36 T



ck Mica and Mica Splittings According to Size.

TENTATIVE METHODS OF TEST
FOR
GRADING NATURAL MICA[1]

A.S.T.M. Designation: D 351 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1932; REVISED, 1933, 1935, 1936.

Scope. 1. These methods cover tests for the grading of all natural block mica and mica splittings for general use according to size, commercial quality, and thickness.

GRADING ACCORDING TO SIZE

Grade. 2. Natural mica shall be graded according to the area of the usable rectangle which can be cut from the specimen and the minimum dimension of one side. The mica in the usable rectangle shall meet the quality requirements specified by the purchaser.

A.S.T.M. Chart. 3. The tentative standard A.S.T.M. chart shown in Fig. 1 (Plate I) shall be used for grading natural block mica and mica splittings according to size.

Method of Grading for Size. 4. The specimen to be graded shall be laid upon the chart so that it covers point *O* and has its maximum and minimum dimensions extending along and covering the lines *OA* and *OB*, respectively. The specimen should be shifted until its usable area completely covers the largest rectangle determined by a diagonal extending from point *O* to or beyond a point on any of the curves, Nos. 6, 5½, 5, 4, 3, 2, 1, or A-1. The number of the curve at greatest distance from *O* cut by the diagonal of the rectangle designates the grade of the specimen.

NOTE.—The A.S.T.M. chart complies closely with the following so-called India grading scale, in general use for many years:

GRADE	AREA OF RECTANGLE, SQ. IN.	MINIMUM DIMENSION OF ONE SIDE
Extra Special	60 to 80	....
Special	48 to 60	....
A-1	36 to 48	4 in.
1	24 to 36	3 in.
2	15 to 24	2 in.
3	10 to 15	2 in.
4	6 to 10	1½ in.
5	3 to 6	1 in.
5½	2½ to 3	1 in.
6	1 to 2½	¾ in.

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-9 on Electrical Insulating Materials.

DETERMINATION OF COMMERCIAL QUALITY

Commercial Quality.

5. The commercial quality of mica shall be judged in terms of the following scale:

QUALITY	DESCRIPTION
Clear	**Free of all mineral and vegetable inclusions, stains, air inclusions, waves or buckles. Hard transparent sheets.**
Clear and Slightly Stained	**Free of all mineral and vegetable inclusions, cracks, waves, and buckles but may contain slight stains and air inclusions.**
Fair Stained	**Free of mineral and vegetable inclusions and cracks. Hard Contains slight air inclusions and is slightly wavy.**
Good Stained	**Free of mineral inclusions and cracks but contains air inclusions, some vegetable inclusions and may be somewhat wavy.**
Stained	**Free of mineral inclusions and cracks but may contain considerable clay and vegetable stains and may be more wavy and softer than the better qualities.**
Heavy Stained	Free of mineral inclusions but contains more clay and vegetable stains than that of Stained and distinctly inferior as regards to rigidity and toughness.
Black Stained and Spotted	Apt to contain some mineral inclusions consisting of magnetite (black), specularite (red), and hydrous iron oxide (yellow).

THICKNESS

Thickness.

6. (*a*) Measurements of the thickness of mica shall be determined with a machinist's micrometer as specified in the Tentative Methods of Test for Thickness of Solid Electrical Insulation (A.S.T.M. Designation: D 374 – 36 T) of the American Society for Testing Materials.[1] In determining thickness of mica which must be held to close tolerance or where two or more specimens are to be measured at once, Method A shall be used. Where the maximum accuracy is not required, Method B may be used.

(*b*) Because of the abrasive nature of mica, the micrometer shall be tested frequently for conformity to the requirements specified in the Tentative Methods D 374. The anvil and spindle shall be cleaned as frequently as necessary to prevent the accumulation of mica dust on their surfaces and to preserve the accuracy of the measurements. To clean, the micrometer shall be closed lightly on a clean sheet of bond paper and the paper moved between the surfaces.

NOTE.—Care must be exercised in moving from one measurement location to another to maintain the surfaces of the anvil and spindle parallel to the surfaces of the specimen at all times so as to avoid scratching the mica and accumulating mica dust under the micrometer surfaces which will cause false readings.

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[1] See p. 1026.

TENTATIVE METHODS OF TESTING UNTREATED PAPER USED IN ELECTRICAL INSULATION[1]

A.S.T.M. Designation: D 202 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1924; REVISED, 1925, 1926, 1927, 1928, 1929,
1930, 1932, 1933, 1934, 1936.

Scope. 1. These methods are intended to apply to untreated paper to be used as an electrical insulator or as a constituent of a composite material used for electrical insulating purposes.

SAMPLING

Sampling. 2. (*a*) From shipments consisting of rolls, a sample of at least 1 sq. yd. in area, cut across the entire width of the roll, shall be taken from every tenth roll in the shipment. From other shipments such as sheets or pads of tape, samples of equivalent area shall be taken in such a manner as to be equally representative of the shipment. In no case shall less than three samples be taken.

NOTE.—It is recommended that several turns of paper from each roll sampled be torn off and discarded before the samples are taken.

(*b*) The tests for physical properties shall be made upon each sample.

(*c*) The tests for acidity, moisture content, ash and for identification of fibers shall be made in duplicate upon portions taken from a composite sample. This composite sample shall be made up of a sufficient number of small pieces, each of approximately 6.5 sq. cm. (1 sq. in.) in area taken in nearly equal amounts from each of the samples taken in accordance with Paragraph (*a*).

(*d*) The required number of samples shall be taken at equal intervals across the sheet, the two end samples being taken at the edges of the sheet after removing any damaged paper. When it is not possible to secure the required number of specimens in this manner in going once across the sheet, the selection across the sheet shall be repeated as many times as necessary until the required number of specimens is secured.

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-9 on Electrical Insulating Materials.

CONDITIONING SAMPLES

Conditioning. 3. Samples shall be conditioned in air maintained at a relative humidity between 60 and 65 per cent as measured with a sling psychrometer or its equivalent. The temperature of the air shall be maintained as constant as possible at some temperature between the limits of 20 and 30° C. (68 and 86° F.). The samples should remain in the conditioned air for not less than 4 hours prior to the tests and should be supported so as to allow a free circulation around each sample. The following physical tests shall be made in the conditioned air: tensile breaking strength, tearing strength, bursting strength, folding endurance, air resistance, absorption, dielectric strength and thickness.

MOISTURE CONTENT

Apparatus. 4. A weighing bottle, evaporating dish, thermometer, constant-temperature oven, chemical balance and desiccator are necessary for the test. The weighing bottle should be of convenient size, about 65 mm. (2.56 in.) in height and 45 mm. (1.77 in.) in diameter with a wide mouth provided with a ground-glass stopper. The chemical balance should be sensitive to 0.1 mg.

Specimen. 5. The moisture content figure is used to calculate the percentage of acidity, size, and ash of the paper to the bone-dry basis. It shall be determined on 2 to 5-g. samples selected in accordance with Section 2 (*c*).

If the moisture content of the paper as received at the purchaser's works is desired or at any other stated time, it shall be made on the sample taken at the definitely stated time by cutting small pieces of approximately 6.5 sq. cm. (1 sq. in.) in area from the required number of rolls or pads of tape in accordance with Section 2 (*a*) and immediately placed into an air-tight container.

NOTE.—Since paper adjusts itself, as regards moisture content, to the humidity of the surrounding atmosphere in a very short time (2 or 3 minutes), special care must be exercised to transfer rapidly the sample from the roll or bundle to the container and from the container to the weighing bottle.

Procedure. 6. The sample before drying shall be weighed in the tared bottle with the stopper in place. The bottle shall then be placed in the oven at 100 to 105° C. (212 to 221° F.), the stopper removed and laid alongside of the bottle and the contents transferred to the drying dish. After one hour, while still in the oven, the sample shall be replaced in the weighing bottle, and the bottle stoppered and transferred to the desiccator. The stopper should be removed while the bottle cools. When the specimen and the bottle have cooled to room temperature, the stopper shall be replaced and the bottle with its contents weighed. This process shall be repeated at intervals of one hour until the difference in weight between two successive weighings is not more than 0.2 per cent of the weight of the specimen.

NOTE.—The weighing bottle or sample should not be touched with the fingers during this test.

Report. 7. The moisture content shall be expressed:

(*a*) as a percentage of the weight of the dry sample, and

(*b*) as a percentage of the weight of the undried sample.

THICKNESS

Apparatus. 8. The thickness shall be determined in accordance with the Tentative Methods of Test for Thickness of Solid Electrical Insulation (A.S.T.M. Designation: D 374 - 36 T) of the American Society for Testing Materials.[1]

Specimens. 9. Specimens shall consist of the original samples obtained in accordance with Section 2 (*a*).

Number of Measurements. 10. At least five measurements of the thickness shall be taken at regular intervals across the entire width of each specimen.

Report. 11. The average, maximum, and minimum thicknesses obtained on each specimen shall be reported.

WEIGHT

Apparatus. 12. The following apparatus will be required:

(*a*) *Weighing Balance.*—A chemical balance or a specially-constructed sheet-weighing balance are necessary for the test. In case a chemical balance is to be used and if it is not in the conditioned atmosphere, a weighing bottle is also necessary. The weighing device shall be accurate to 0.25 per cent of the load applied.

(*b*) *Knife and Trimming Board.*—A sharp knife or accurate trimming board.

(*c*) *Scale.*—The scale used in measuring the specimen shall be capable of measuring to an accuracy of 0.25 per cent of the smallest dimension to be measured.

Specimens. 13. Duplicate specimens shall be taken from as widely separated portions as possible from each of the samples obtained in accordance with Section 2 (*a*) and conditioned in accordance with Section 3.

Procedure. 14. (*a*) Each specimen while in the conditioned atmosphere (see Section 3) shall be cut accurately to any convenient size and accurately weighed. Specimens of sufficient size to weigh at least from 3 to 5 g. (0.11 to 0.18 oz.) should be taken. If it is not possible to do the weighing in the conditioned atmosphere, the specimen shall be placed in a weighing bottle and tightly stoppered with a ground-glass stopper before being removed from the conditioned atmosphere.

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[1] See p. 1026.

(*b*) The weight shall be calculated to and expressed as grams per square meter.

NOTE.—Grams per square meter times 0.00142 equals pounds per 1000 sq. in., from which the weight in pounds per ream of any size can be calculated if desired.

APPARENT DENSITY

Apparent Density. 15. The apparent density shall be calculated from the thickness results obtained from the conditioned specimens (as prescribed in Sections 8 to 11) and the weight (determined in accordance with Sections 12 to 14) by means of the following formula:

$$\text{Apparent Density, g. per cu. cm.} = \frac{\text{Wt., g. per sq. m.}}{\text{Thickness, in.}} \times 0.0000394$$

TENSILE BREAKING STRENGTH

Apparatus. 16. (*a*) A testing machine of the dead-weight pendulum type suitably designed for testing paper shall be used. The machine shall preferably be power driven.

(*b*) The capacity of the machine shall not exceed 113 kg. (250 lb.).

(*c*) The machine shall be graduated to read 1 lb. or 1 kg. or less per scale division for testing paper breaking at 22.7 kg. (50 lb.) or over, and to 0.5 lb. or 0.5 kg. or less for testing paper breaking under 22.7 kg. (50 lb.).

Specimen. 17. From each of the samples selected in accordance with Section 2 (*a*), specimens shall be cut at least ten in the machine direction and if practicable, ten in the cross-machine direction. The specimens shall not exceed 2.54 cm. (1 in.) in width and shall be 25.4 cm. (10 in.) in length with clean-cut edges.

Procedure. 18. (*a*) The ratio of the clearance distance between jaws to the width of the specimen shall not be less than 5 to 1 nor more than 10 to 1.

(*b*) The rate of travel of the movable jaw shall be constant. It shall preferably be 30.5 cm. (12 in.) per minute, but it may be within the limits of 28 cm. (11 in.) and 33 cm. (13 in.) per minute provided it is constant.

(*c*) All readings obtained when the paper breaks at or in the jaws shall be rejected.

Report. 19. (*a*) The results of the machine-direction specimens and the cross-machine-direction specimens shall be reported separately.

(*b*) The results shall be reported in kilograms or pounds together with the width of the specimen in centimeters or inches and also the average thickness.

(*c*) The maximum, minimum, and average breaking load shall be reported for the machine direction and the cross-machine direction.

TEARING STRENGTH

Apparatus. 20. The testing machine shall be of the pendulum impulse type so designed as to produce a tear approximately 4.2 cm. (1.66 in.) long. The knife mounted on the machine to cut the slit for the tear shall be maintained sharp.

Specimen. 21. The specimens shall be taken from the original samples obtained in accordance with Section 2 (*a*) and shall be cut 6.3 cm. (2.5 in.) in width and at least 6.3 cm. (2.5 in.) in length. Enough specimens shall be cut so that at least five readings in the machine direction and five readings in the cross-direction, if possible, can be obtained for each original sample.

Method. 22. Enough paper shall be torn so that the readings on the machine shall be not less than 10 nor more than 20 g., unless one paper alone yields a reading greater than 20 g., in which case only one paper shall be torn at one time. The specimens shall be so arranged that an equal number of tears originating from opposite edges of the specimens will be produced. Readings obtained when a tear deviates more than 6.3 mm. (0.25 in.) from a straight line, shall be rejected. The readings obtained shall be multiplied by the instrument constant corresponding to the number of sheets torn.

Report. 23. (*a*) The tearing strengths obtained on the machine-direction specimens and on the cross-direction specimens shall be reported separately in grams.

(*b*) The average, the maximum, and the minimum tearing strengths shall be reported for the machine-direction specimens. If possible, similar results shall be reported for the cross-direction specimens.

BURSTING STRENGTH

Apparatus. 24. The testing machine shall have a circular flexible diaphragm 6.44 sq. cm. (1 sq. in.) in area. The pressure chamber shall be filled with glycerin or other suitable pressure medium and shall contain no air spaces. The test specimen shall be held in position over the diaphragm in a clamp having a circular hole approximately 6.44 sq. cm. (1 sq. in.) in area so that the diaphragm will force the paper into the hole when pressure is applied under the diaphragm. The pressure exerted on the diaphragm shall be indicated on a dial, graduated to at least 0.23 kg. (0.5 lb.) for papers giving bursting strengths 18 kg. (40 lb.) or under. A dial graduated 0.45 kg. (1 lb.) may be used in testing papers which give higher bursting strengths. The machine may be either hand-operated or power-driven, the latter being preferable.

Specimen. 25. If practicable, the specimen shall be so cut from the stock as to permit ten bursting tests on a line across the sheet or roll.

Procedure. 26. Ten bursts shall be made, five with one side of the paper uppermost and five with the other side uppermost. The testing machine shall be driven at a uniform speed of 120 r.p.m. until the specimen bursts.

Report. 27. The report shall include the average, the maximum, and the minimum results obtained.

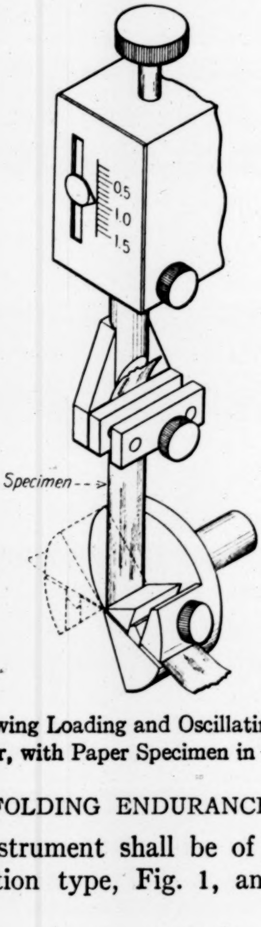

FIG. 1.—Sketch Showing Loading and Oscillating Clamps of Folding Endurance Tester, with Paper Specimen in Testing Position.

FOLDING ENDURANCE

Apparatus. 28. The testing instrument shall be of the adjustable-tension, vertical test-strip position type, Fig. 1, and shall consist of the following:

(*a*) A loading clamp and an oscillating clamp mounted in the same plane. The upper or loading clamp shall have a suitable clamping device, constrained to a vertical movement without rotation. A spring shall be attached to the loading clamp that will give different tensions from 0 to 1.5 kg. dependent upon the displacement. The deflection of the spring when loaded shall not be less than 17 mm. per kg.

(*b*) The lower or oscillating clamp shall be provided with two jaws, each of which terminate in a cylindrical edge near the axis of rotation. The two edges shall be 0.76 mm. ± 0.03 mm. (0.031 in. ± 0.001 in.) in diameter, and not less than 19 mm. (0.748 in.) in length. They shall be parallel to each other and to the axis of rotation. The jaws shall be smooth over all surfaces which come in contact with the paper during the folding cycle. The rotary oscillating movement of the folding clamp shall be such as to fold the paper through an angle of 135 deg. ± 5 deg., to both right and left of the position of zero fold. The folding speed shall be between 140 and 210 double folds per minute.

(*c*) The width of the slot (distance separating folding surfaces) in the oscillating clamp shall be greater than the uncompressed thickness of the paper being tested but shall not exceed it more than 0.25 mm. (0.01 in.).

(*d*) A power-driven device for imparting a rotary oscillating motion of constant period to the folding clamp.

(*e*) A device for registering the number of double folds required to sever the specimen.

Specimens

29. The specimens shall be taken from the original samples obtained in accordance with Section 2 (*a*) and shall be cut 15 mm. (0.59 in.) in width and with a length such as to insure a firm grip in the jaws without buckling. Not less than 10 strips cut with the machine direction parallel with the strip length and, if practicable, 10 strips cut in the cross-machine direction shall be tested. The specimens shall be conditioned in accordance with Section 3.

Procedure.

30. (*a*) The oscillating clamp shall be placed in the position of zero fold. A 1.0-kg. weight shall be placed on top of the plunger and the plunger clamped in position when depressed under this load. The specimen shall then be clamped firmly and squarely in the jaws with the surface of the specimen lying wholly within one plane and not touching the jaw mounting-plate. The specimen shall be handled by the ends and not touched with the hands in the region which is to be folded. The specified tension shall then be applied to the test strip by releasing the plunger. If the reading of the load indicator has changed, it shall be reset by means of the adjusting screw to agree with the reading obtained when the weight was applied. The strip shall be folded at a uniform rate until it is severed at the crease. The number of double folds required to sever the specimen shall be recorded.

(*b*) If a tension of 1.0 kg. is too great or too little to afford practical test results, a greater or lesser tension than 1.0 kg. may be used.

Calibration. 31. (*a*) All working parts shall be in good condition, well oiled, and in proper adjustment. Particular care shall be given to make certain that the folding edges are free from rust or dirt.

(*b*) The plunger friction shall be measured by determining the additional load required to move the plunger perceptibly when displaced under a load of 1.0 kg. or the load tension used in testing. The additional load required shall not be greater than 25 g.

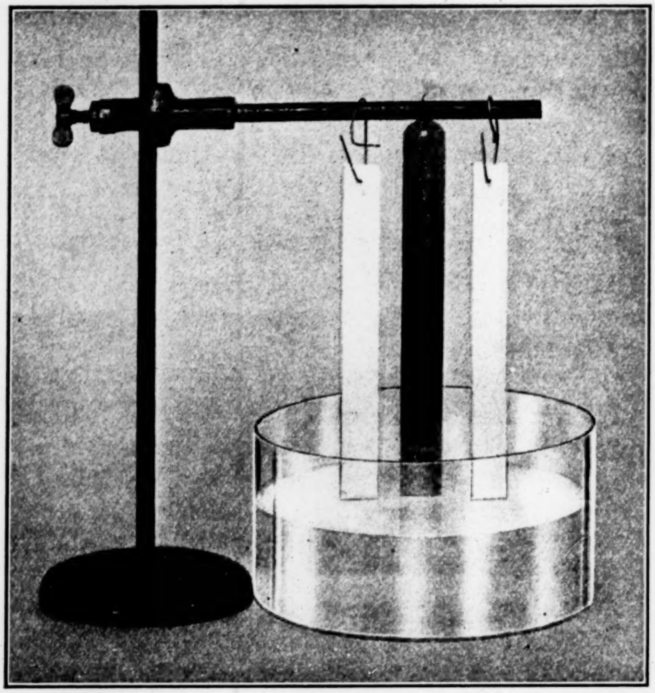

FIG. 2.—Apparatus for Absorption Test.

(*c*) The change in tension due to eccentricity of rotation of folding edges shall be measured as follows: Place a test strip of strong paper, cut in the machine direction, of the proper thickness in the tester in the same manner in which a folding test would be made, and apply a tension of 1.0 kg. or that used in the testing. Rotate the lower jaw slowly throughout the entire folding cycle and measure the maximum change in displacement of the plunger to an accuracy of 0.10 mm. (0.004 in.). The amount of load required to produce the same displacement shall not be greater than 35 g.

Report. 32. The report shall include the number of tests, and the average, the maximum, and the minimum results for both of the principal directions of the paper. The results shall be expressed as M.I.T. double folds at the tension used. Tests run on strips having their length in the machine direction shall be designated as those of "machine direction." In reporting average results, all digits after the first two shall be rounded to zeros.

ABSORPTION

(Rise of Water)

Apparatus. 33. A suitable container and support for specimens and scale is shown in Fig. 2.

Specimens. 34. Ten strips 2.5 cm. (1 in.) in width and at least 12.5 cm. (5 in.) in length shall be cut from the samples obtained in accordance with Section 2 (*a*), five being cut parallel with the machine direction of the paper and five being cut parallel with the cross-direction of the paper.

Procedure. 35. The specimens shall be suspended vertically with one end dipping 3.2 mm. (0.125 in.) in distilled water at room temperature.

After five minutes of suspension, the rise of the water in the paper above the water level shall be noted. The rise may be measured by reading directly from the scale the height of absorption.

Report. 36. The rise of water shall be reported in millimeters to the nearest 3 mm. or in inches to the nearest $\frac{1}{8}$ in.

AIR RESISTANCE

Apparatus. 37. (*a*) The instrument shall consist of two aluminum open-top cylinders, one of which is inverted and slides into the other which is fixed. The movable cylinder shall be provided with a circular aperture in the closed end and a flat ring clamp for holding the paper specimen across this aperture.

(*b*) The fixed cylinder shall be 25.4 cm. (10 in.) in height and shall have an external diameter of 8.60 cm. (3.38 in.) and an internal diameter of 8.25 cm. (3.25 in.). Four slender bars, each 18.5 cm. (7.3 in.) long, 3 mm. (0.12 in.) wide and approximately 1.5 mm. (0.06 in.) thick shall be mounted vertically and equi-distantly on the inner surface of the fixed cylinder to act as guide tracks for the movable cylinder. The movable cylinder shall be graduated in units of 50 ml. and shall have a total range of 350 ml. It shall be 25.4 cm. (10 in.) high and shall have an external diameter of 7.62 cm. (3.00 in.) and an internal diameter of 7.35 cm. (2.90 in.). It shall weigh, including the flat ring clamp and the two knurled nuts, 567 g. ± 0.5 g. (20 oz. ± 0.018 oz.). The movable cylinder and the flat ring clamp shall have a concentric circular aperture of 6.44 sq. cm. (1.00 sq. in.) in area. When this aperture is too large for the specimen a similar movable cylinder and flat ring clamp having a concentric circular aperture of 1.61 sq. cm. (0.25 sq. in.) in area shall be used.

NOTE.—Results obtained with apertures of different areas are not directly proportional to the areas of the apertures. The proportionality factor must be determined by experiment.

Specimen. 38. The specimens shall be not less than 3.5 cm. (1.36 in.) nor more than 5.1 cm. (2.0 in.) in width cut from the original samples, taken in accordance with Section 2 (*a*) and shall be as long as the width of the original roll of paper. If the specimens are selected from pads of tape they shall be not less than 2.1 cm. (0.81 in.) nor more than 5.1 cm. (2.0 in.) wide and at least 30 cm. (12 in.) long. There shall be as many specimens as there are original samples.

Procedure. 39. The fixed cylinder shall be placed on a rigid support so that its sides are vertical. A lubricating oil with viscosity of 60 to 70 seconds Saybolt at 37.8° C. (100° F.) shall be placed in it to a depth of 12.7 cm. (5 in.). The specimen (one thickness only) shall be secured tightly under the clamp on the movable cylinder completely covering the aperture. The movable cylinder is then floated on the lubricating oil. The time required for the displacement of a certain amount of air shall be noted with a stop-watch. If possible, the amount of air displaced should be such that the time of displacement is not less than 20 seconds. The apparatus with its content of lubricating oil shall be at the temperature of the conditioning room when the readings are taken. The time in seconds required for the displacement of 100 ml. (6.1 cu. in.) of air through a circular area (one side only) of 6.44 sq. cm. (1 sq. in.) of the paper is known as the air resistance of the paper.

NOTE.—The clamp shall be tested for leakage by substituting a piece of tinfoil 0.05 mm. (0.002 in.) in thickness for the paper and testing in the manner described above. When so tested, the leakage shall not exceed the rate of 50 ml. in five hours.

The proper procedure for clamping the specimen or tinfoil is to turn both knurled nuts down onto the clamp simultaneously. If only one nut at a time is turned down, the clamp will not fit flat on the specimen and will consequently have an avoidable leak.

Oil is used in preference to distilled water because it does not corrode aluminum whereas distilled water does.

Precautions should be taken to avoid subjecting the apparatus to vibration as this condition would increase the rate of air displacement.

Report. 40. The report shall include the following:

(*a*) the number of seconds required for the displacement of 100 ml. (6.1 cu. in.) of air;

(*b*) the area of paper through which the air was displaced;

(*c*) the thickness of the paper as obtained under Sections 8 to 11;

(*d*) the room temperature.

NOTE.—The following values show the probable accuracy obtainable in the air-resistance tests:

AIR RESISTANCE	ACCURACY
40 seconds	± 5 per cent
100 seconds	± 6 per cent
200 seconds	± 8 per cent
300 seconds	± 10 per cent

FIBER COMPOSITION

Fiber Composition. 41. The percentage of various fibers contained in samples shall be determined in accordance with the Standard Methods of Analysis of Roofing Felt for Fiber Composition (A.S.T.M. Designation: D 272) of the American Society for Testing Materials.[1]

ASH

Apparatus. 42. A suitable crucible such as platinum, nickel or porcelain, a balance sensitive to 0.1 mg., and a desiccator are necessary for the test.

Specimen. 43. Not less than 2 g. of dry, finely-divided paper from the "moisture determination" sample as obtained in accordance with Section 6 shall be used.

Procedure. 44. The sample shall be transferred rapidly from the weighing bottle containing the dried sample into the crucible. The weighing bottle shall immediately be re-stoppered and re-weighed, and the exact weight of the sample obtained by taking the difference in weights of the weighing bottle and the sample. The sample shall be completely ignited in the crucible, preferably in a muffle furnace, all precautions being taken to prevent loss of ash or sample. The residue of incombustible mineral matter (ash) shall be desiccated, cooled and weighed, and the amount computed as a percentage of the weight of the dried sample.

Report. 45. The amount of ash shall be reported as a percentage of the weight of the dry sample (see Section 7 (*a*)) and also as a percentage of the weight of the undried sample (see Section 7 (*b*)).

ACIDITY OR ALKALINITY

Apparatus. 46. (*a*) A hot water bath, electric hot plate, motor with stirrer, 50-ml. glass burette graduated to 0.1 ml., 250-ml. wide-mouth Erlenmeyer flasks, thermometer graduated to 1° C., covering the range from 50 to 100° C., and a filtering apparatus, are required for the test.

(*b*) The Erlenmeyer flasks and the stirrer shall be of acid-resistant and alkali-resistant glass. The stirrer shall consist of a glass shaft, one end of which shall be fitted to a chuck attached to the motor shaft (see Fig. 3). The other end of the stirrer shall be fashioned into a two-bladed propeller, each blade to be approximately 15 mm. (0.59 in.) long and 6 mm. (0.24 in.) wide. The pitch of the blades and the direction of rotation shall be such as to produce a downward current along the glass shaft when the stirrer is rotated in the liquid, thus preventing spattering.

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 1162.

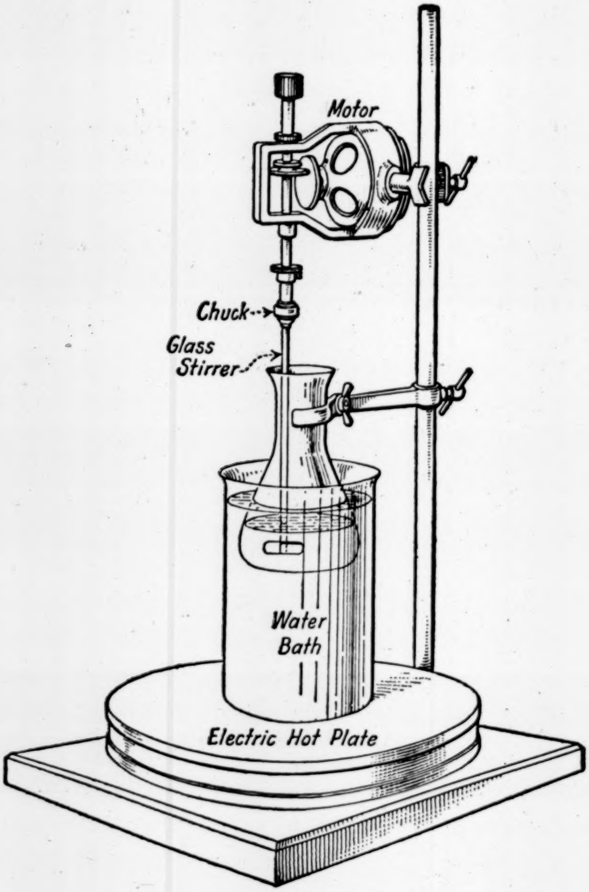

FIG. 3.—Extraction Apparatus.

(*c*) The following reagents shall be required: Solutions of sodium hydroxide (NaOH) and sulfuric acid (H_2SO_4) in water, each being 0.01 *N* in strength; solution of 0.5 g. of phenolphthalein dissolved in 100 ml. of c.p. ethyl alcohol.

Sample. 47. From the original samples obtained in accordance with Section 2 (*a*), a composite sample of at least 5 g. (0.175 oz.) shall be cut into small pieces, approximately 1 cm. (0.4 in.) square. The sample shall be thoroughly mixed, and during preparation contamination by handling shall be avoided.

Procedure.

48. (*a*) *Extraction.*—One gram of the composite sample shall be placed in a 250-ml. Erlenmeyer flask and 100 ml. of boiling, distilled water added. The flask shall then be clamped in position in a water bath[1] heated to 100° C. on a hot plate. The level of the water in the bath shall be slightly above the level of that in the flask, and the temperature of the contents of the flask shall remain at least as high as 95° C. during the stirring operation. The stirrer shall be mounted so that the blades are within 3 mm. (0.12 in.) of the bottom of the flask and offset from the center in order to obtain best beating action. The stirrer shall be driven at a speed of 4000 to 5000 r.p.m. for 5 minutes. At the end of this period the sample should have been thoroughly pulped. For papers unusually difficult to pulp, the period of stirring shall be increased to 10 minutes.[2]

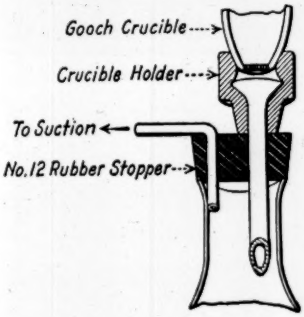

FIG. 4.—Filtration Apparatus.

NOTE.—It has been definitely determined that 3000 r.p.m. is too low to pulp the sample effectively within 5 minutes.

(*b*) *Titration.*—Immediately after the sample has been pulped, the contents of the flask shall be filtered rapidly into another 250-ml. Erlenmeyer flask without washing.

NOTE.—It is important that the filtration of the extract be accomplished as promptly as possible after disintegration to prevent re-absorption of acidic or alkaline material from the extract by the pulp as the temperature falls. A convenient method consists of a 25-ml. porcelain Gooch crucible and holder assembly, like that shown in Fig. 4. The pulp forms a filter mat of itself over the perforations in the bottom of the crucible and the first portion of the filtrate is re-filtered to catch the fibers which go through during the formation of the mat.

The filtered extract shall be boiled for 3 minutes and immediately titrated before the temperature falls below 80° C., thus eliminating the error due to dissolved carbon dioxide.

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[1] At high altitudes a salt bath will be necessary to obtain the temperature required.

[2] Any other method of pulping the sample as rapidly and thoroughly, while maintaining a temperature of 95° C. within the flask during extraction, should prove satisfactory.

If the extract is acidic, it is titrated with $0.01N$ NaOH, using 5 drops of the specified phenolphthalein solution as indicator. The end-point is determined by the appearance of a definite pink color. If the extract is alkaline, a small excess of $0.01N$ H_2SO_4 is added and the titration then completed with $0.01N$ NaOH as described above.

NOTE.—To find the proper color transformation at the end-point, a blank titration should be made on boiling distilled water under the above specified conditions.

The number of milliliters of titer solution shall be recorded, together with the temperature and volume of the solution taken immediately upon the completion of the titration, as these figures enter into the blank correction for the volume error (E_v).

Report. 49. (*a*) *Blank Correction.*—The correction for the blank error in the titration shall be made by running a blank in parallel with the actual determination using a volume of pure distilled water equal to that of the extract at the end-point. If the solution is acidic, this blank correction shall be subtracted from the volume of titer used; if alkaline, the correction shall be added.

(*b*) *Calculation.*—The acidity or alkalinity shall be calculated from the following equation:

$$\text{Percentage acidity (or alkalinity)} = \left\{\begin{matrix}\text{milliliters titer}\\ \text{solution (corrected)}\end{matrix}\right\} \times \frac{\text{normality}}{1000} \times 40 \times 100$$

A simpler form is:

$$\text{Percentage acidity (or alkalinity)} = \left\{\begin{matrix}\text{milliliters}\\ \text{titer (corrected)}\end{matrix}\right\} \times \text{normality} \times 4$$

(*c*) *Expression of Results.*—The results shall be expressed as the equivalent weight per cent of NaOH if the extract is acidic, or as equivalent weight per cent of SO_3 if the extract is alkaline; this percentage being based on the weight of the air-dry sample in grams.

NOTE.—SO_3 is used rather than H_2SO_4 in this calculation as the equivalent weight of SO_3 is identical with that of NaOH, and this makes it possible to express acidity or alkalinity in directly comparable terms.

(*d*) *Number of Tests.*—At least two samples shall be carried through the foregoing procedure. If in duplicate samples the values of percentage acidity or alkalinity do not agree within 0.005, the determinations shall be repeated.

NOTE.—There is given in an appendix to the report of Committee D-9 for 1926,[1] information regarding the details of the foregoing method, and reasons are presented for the selection of the conditions specified.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 461 (1926).

SURVEY FOR CONDUCTING PATHS

50. The survey for conducting paths in untreated insulating paper is a test to determine the number of conducting paths in the paper as indicated by the number of electrical breakdowns (or points of excessive current flow in thin papers (see Section 50 (*b*)) when relatively large areas of the paper are subjected to a voltage somewhat lower in value than the dielectric strength of the paper when tested in accordance with Sections 2 to 12 of the Tentative Methods of Testing Sheet, Tape, and Molded Insulating Materials for Dielectric Strength (A.S.T.M. Designation: D 149 – 36 T) of the American Society for Testing Materials.[1] **Scope.**

51. (*a*) The survey shall be made by passing a specimen of the paper between metallic electrodes across which a voltage is impressed. The arrangement of the apparatus may be of any convenient form which will allow the application of the required voltage to a specimen of relatively large area, and will allow the electrical breakdowns to be indicated so that the number of these may be counted. **Apparatus.**

(*b*) For papers having a thickness of 0.038 mm. (0.0015 in.) or less it has been found preferable to use a detecting device such as a telephone receiver to detect the excessive current through the conducting paths rather than to allow complete electrical breakdown of the specimen. Also, it is preferable to pass one electrode over the paper rather than to draw the paper through between the electrodes.

52. The specimen shall be of relatively large area, such as a pad of tape, or a sheet from each sample of paper (see Section 2 (*a*)). **Specimens.**

53. The survey shall be made by passing the specimen between the metallic electrodes at a speed of 30 to 60 ft. per minute. The voltage impressed across the electrodes shall be 100 volts per mil thickness of the specimen if alternating voltage is used, or 141 volts per mil thickness of the specimen if direct voltage is used. **Procedure.**

NOTE 1.—If the voltage values specified above prove inconvenient of application, a lower voltage may be used, in which case it is necessary to establish a relationship between the conducting paths at this voltage and at the specified voltage. A lower value of conducting paths will be obtained at the lower voltage.

NOTE 2.—A description of equipment and a procedure which have been found suitable for making this survey of conducting paths in different thicknesses of paper appears in the Appendix.

54. The report shall include the following: **Report.**

(*a*) The total number of conducting paths and the conducting paths per unit area.

(*b*) The length, width, area, and thickness of the specimen.

(*c*) The voltage applied expressed in volts, and volts per mil thickness of specimen.

(*d*) The speed of the paper.

---

[1] See p. 919.

DETERIORATION

Apparatus. 55. (*a*) *Baking Oven.*—An electrically-heated oven, equipped with an efficient means of circulating air *within* or *through* the heated chamber, and a suitable fixture upon which the paper specimens may be mounted, shall be used. In case the air is circulated *within* the body of the oven, for example by fan, it is required that the fixture upon which the specimens are mounted be a turntable rotating within the oven at a speed of about 20 r.p.m., so that the specimens shall be uniformly exposed to the oven conditions. In the case of heated air circulating *through* the oven, the fixture holding the specimens may be stationary but it is essential that it shall be mounted so as to be at least 4 in. from the oven walls at any point to permit adequate circulation in all parts of the oven, and the design should be such that there shall be an air velocity of at least one foot per second through the oven.

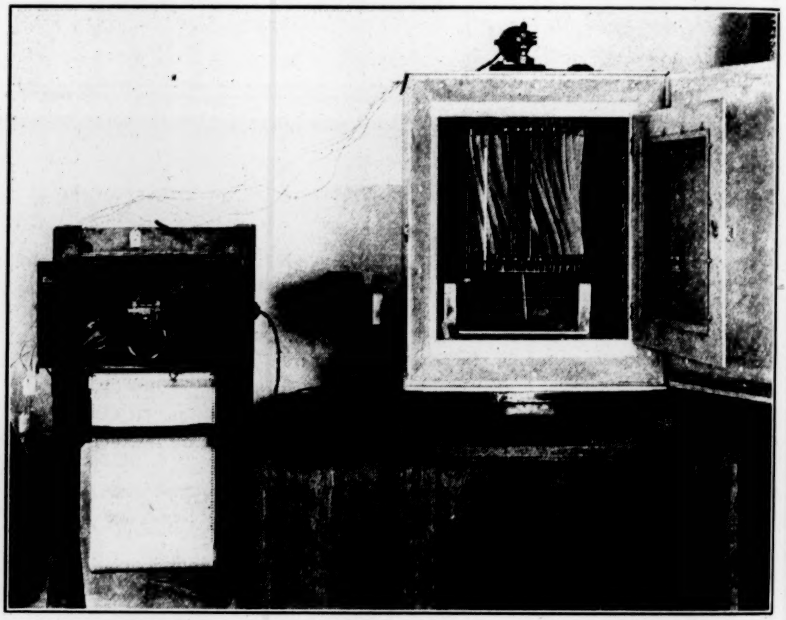


FIG. 5.—Baking Oven Equipped for Circulating Air Within the Oven.

(*b*) *Testing Equipment.*—In addition to the oven it is necessary to provide testing machines for making physical measurements on the baked specimens. The tests may be tensile breaking strength, tearing strength, folding endurance, or brittleness.[1]

---

[1] Another sensitive test for paper deterioration is brittleness strength. This does not appear in the method, but will be included as soon as the test is developed by the committee.

Specimens.

56. (*a*) The specimens shall be at least ½ in. in width and at least 12 in. in length, and shall be cut from samples obtained in accordance with Section 2 (*a*). At least five groups of 5 specimens each shall be selected for each type of physical test noted in Section 55 (*b*). These groups of specimens shall be selected from the gross sample in some rational manner, so as to represent any known or suspected differences in the quality of the product.

Baking.

57. (*a*) The specimens shall be mounted on the fixture as shown in Figs. 5 and 6. In the case of the rotating turntable, Fig. 5, the specimens shall be mounted at such an angle that they will assist, fan-like, in stirring the air within the oven. In the case of a stationary scheme of mounting, Fig. 6, the specimens shall be mounted vertically. The rows of clips supporting the specimens, top and bottom, should be set alternately at 45-deg. angles across the oven so that the air flowing horizontally through the oven would pass between these staggered rows, turbine fashion, and assist in keeping the temperature uniform in all parts of the oven.

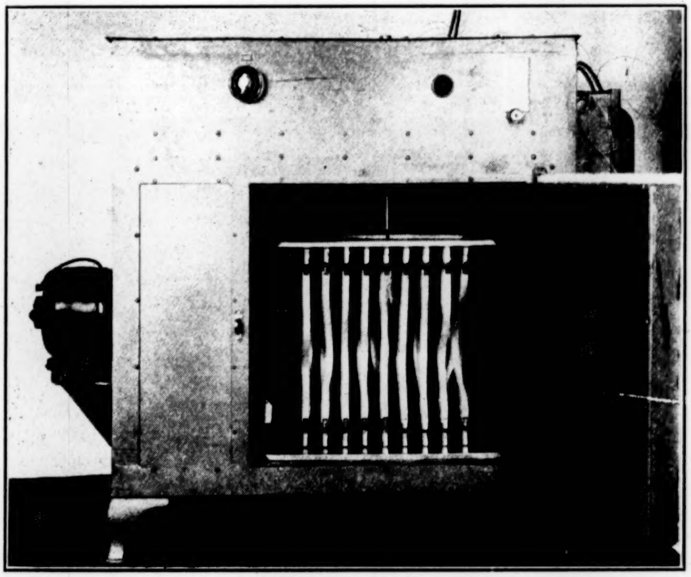


FIG. 6.—Baking Oven Equipped for Circulating Air Through the Oven.

The fixture, readily removable from the oven for mounting the specimens, shall be put in place, and the oven, previously brought to 135° C., shall be closed. Air shall be circulated, as previously indicated, and the temperature shall be maintained at 135° C. ± 2° C.

for 96 hours.[1] It is imperative that the differences in temperature in different parts of the oven shall not exceed 2° C.

Conditioning and Testing.

58. The baked specimens shall be removed from the mounting fixture, care being taken not to damage the strips, and shall be conditioned in a humidity room at 60 to 65 per cent relative humidity and at a temperature of 68 to 86° F., for a period of 4 hours. They shall then be tested in this conditioned room for tensile breaking strength, tearing strength, folding endurance, or brittleness.[2]

Report.

59. The maximum, minimum and average values shall be reported for each type of test used.

---

[1] These temperature and time conditions are satisfactory for the more stable types of cable insulating papers. Less severe conditions should be used for other insulating papers and these will be included as soon as they are developed by the committee.

[2] Another sensitive test for paper deterioration is brittleness strength. This does not appear in the method, but will be included as soon as the test is developed by the committee.

APPENDIX

DESCRIPTION OF APPARATUS FOR A SURVEY FOR CONDUCTING PATHS IN UNTREATED INSULATING PAPERS

Equipment and procedure which have been found to be suitable for making the survey of conducting paths for different thicknesses of paper are as follows:

For Paper Having a Thickness of 0.038 mm. (0.0015 in.) or Under.—For paper having a thickness of 0.038 mm. (0.0015 in.) or under, a brass plate, a brass roller with an insulated handle, a pair of telephone receivers having a total resistance of 3000 ohms, a resistor of 80,000 ohms, and a source of direct voltage of 110 volts is used in this test. The brass plate is 31.8 cm. (12.5 in.) in width and 38.7 cm. (15.25 in.) in length and is machined and polished until its surface is level and smooth. The brass roller has a diameter of 5.08 cm. (2 in.) and a face of 2.54 cm. (1.00 in.) in width. The surface of the roller should be accurately cylindrical and polished so that it will always make a line contact when it is rolled over the brass plate in any direction. A brass plate which will warp the least is best obtained by casting a plate at least 2.54 cm. (1.00 in.) in thickness and dressing down the surface to the desired smoothness.

The size of the specimen is 38.7 cm. (15.25 in.) square, and is prepared for test as follows: Using a soft pencil (No. 2) and bearing lightly, mark off 12 swaths on each specimen (see Fig. A1). Each swath is 2.54 cm. (1 in.) in width and 30 cm. (12 in.) in length. The swaths are spaced 0.63 cm. (0.25 in.) from each other. The specimen is then placed on the brass plate in such a manner that the ends of all the swaths are spaced 0.63 cm. (0.25 in.) from the edges of the brass plate. The specimen may be held in position by means of two weights as shown in Fig. A1.

Connect the brass roller to one pole of the 110-volt circuit. Connect the brass plate, the 80,000-ohm resistance and the telephone receivers in series to the other pole of the 110-volt circuit. (See Fig. A1.) Run the brass roller once over each swath slowly in succession and count the clicks audible in the telephone receivers. Each click is considered to represent a conducting path. The total number of clicks counted on all the specimens divided by the total area of all the swaths of all the specimens, is the number of conducting paths per unit area.

For Paper Having a Thickness Greater Than 0.038 mm. (0.0015 in.) and Less Than 0.76 mm. (0.030 in.).—For paper having a thickness greater than 0.038 mm. (0.0015 in.) and less than 0.76 mm. (0.030 in.) a transformer with regulating equipment to give the required voltage, a voltmeter, a source of alternating voltage, a brass plate and a set of brass rollers are used. The brass plate is 15.2 cm. (6 in.) in width and 122 cm. (48 in.) in length and is machined and polished until its surface is level and smooth. Each brass roller has a diameter of 3.81 cm. (1.5 in.) and a face 2.54 cm. (1 in.) in width. The surface of each brass roller is accurately cylindrical and polished so that it makes a line contact when it is placed in its position on the brass plate. The brass rollers are mounted in two parallel rows above the brass plate in such a manner as to permit each individual roller to be raised away from the brass plate or lowered to make a line contact with it. The rollers in each row are spaced and have a common geometric axis. The axes of the two rows of rollers are parallel to each other and also to the long edges of the brass plate. The rollers in one row are staggered with respect to the rollers in the other row so that the surface of paper passing under the first row of rollers will be partially overlapped by the second row of rollers (see Fig. A2). The entire surface of the paper makes contact with the rollers at least once and a part of the surface of the paper will make contact twice. The rollers and plate are adequately insulated from each other.

The specimen is 7.61 meters (25 ft.) in length. Place the specimen between the brass plate and the brass rollers. During the test period the moisture content of the specimen shall not exceed 7 per cent. Lower the brass rollers to make contact with the specimen. Before connecting the transformer to the source of alternating voltage, connect the brass plate to one of the high-voltage terminals of the transformer, and the brass rollers, in multiple, to the other high-voltage terminal of the transformer. Then connect the low-voltage side of the transformer with its regulating equipment to the source of alternating voltage. Adjust the voltage between the brass plate and the brass rollers to the required value (100 volts per mil thickness of the specimen). Pass the specimen along between the rollers and the plate at a speed not to exceed 9.75 m. (32 ft.) per minute and count the number of holes burned in the specimen. Each hole shall be considered as representing a conducting path. The total number of holes counted in all the specimens divided by the total area covered (one side only) of all the specimens is the number of conducting paths per unit area.

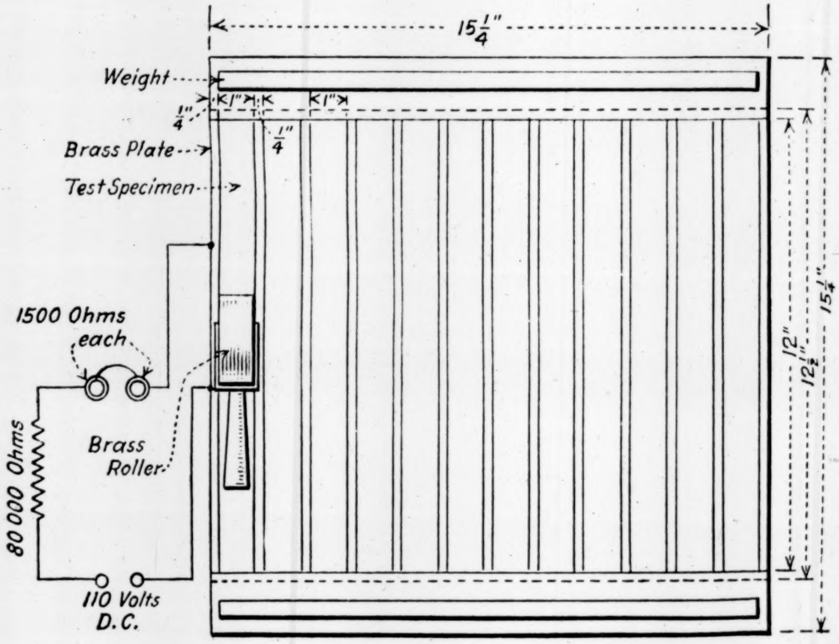


FIG. A1.—Arrangement of Apparatus for Surveying Thin Paper for Conducting Paths.

NOTE.—*Caution:* Disconnect the transformer from the source of alternating voltage before proceeding to place the next specimen between the brass plate and brass rollers.

Specimens in the form of pads of tape may be conveniently tested with an apparatus somewhat similar to the above wherein the pad is mounted on a suitable drum and the entire length of the paper in the pad rerolled on to a second drum, the paper meanwhile passing between two cylindrical rollers across which voltage is applied. The lower roller is somewhat wider than the tape and the upper roller somewhat narrower to prevent arcing through the air between the rollers. The conducting paths are counted by means of a relay and mechanical counter.

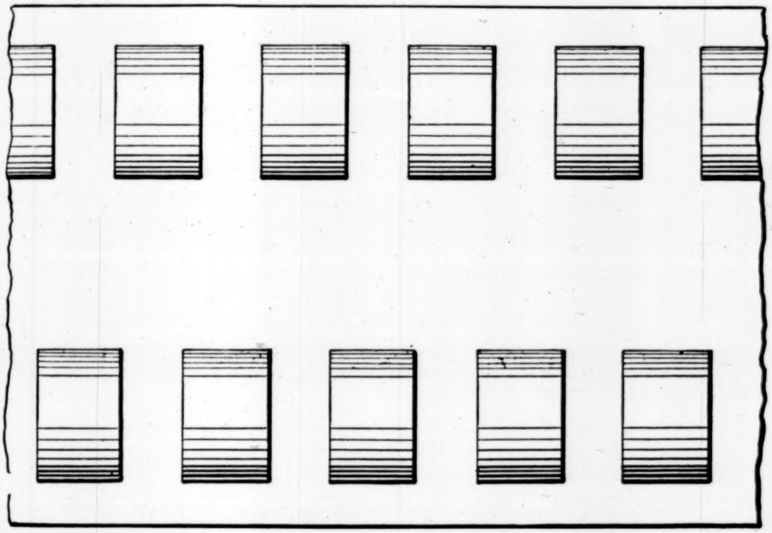
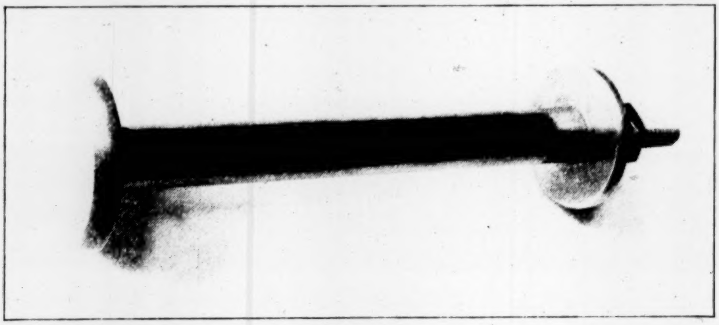
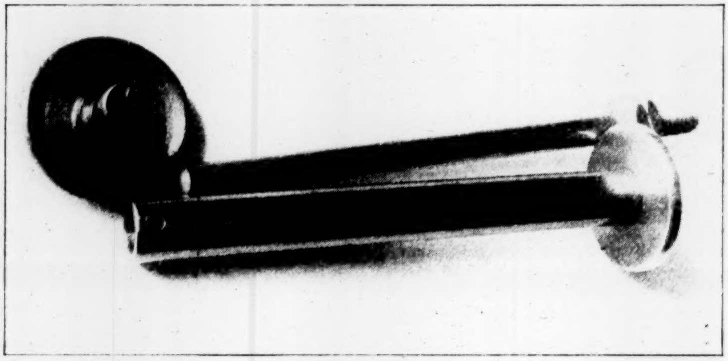


FIG. A2.—Arrangement of Brass Rollers Used in Surveying Paper for Conducting Paths.

For Paper Having a Thickness of 0.76 mm. (0.030 in.) or Over.—For paper having a thickness of 0.76 mm. (0.030 in.) or over a transformer with regulating equipment to give the required voltage, a voltmeter, a source of alternating voltage, a brass plate and a set of disc electrodes are used. The brass plate is 20.3 cm. (8 in.) in width and 122 cm. (48 in.) in length and is machined and polished until its surface is level and smooth. The contact surface of the disc electrodes has a diameter of 3.81 cm. (1.5 in.) with edges rounded to a curvature of 0.64 cm. (0.25 in.) radius. Figure A3 (*a*) shows a convenient design and Fig. A3 (*b*) shows the parts unassembled. The contact surface of each electrode is machined and polished until it is level and smooth and makes an accurate surface contact when it is placed in its position on the brass plate. The disk electrodes are mounted in four parallel rows above the brass plate in such a manner as to permit each individual electrode to be raised away from the brass plate or lowered to make an accurate surface contact with the plate. The four rows of electrodes are parallel to the long edges of the brass plate. The electrodes in one row are staggered with respect to the electrodes in each of the other rows so that the surface of a sheet of paper passing under the electrodes of the first row will be partially overlapped by the electrodes in the second row. Likewise, the surface of paper passing under the electrodes of the second row will be partially overlapped by the electrodes in the third row. And finally, the surface of paper passing under the electrodes of the first and third rows will be partially overlapped by the electrodes in the fourth row. When a sheet of paper has been passed under these four rows of electrodes, the entire surface of the paper will have made contact with the electrodes at least once and a part of the paper surface will have made contact twice. The electrodes and the brass plate should be adequately insulated from each other.



(*a*) Assembled.



(*b*) Unassembled.

FIG. A3.—Disk Electrode for Surveying Paper Over 0.76 mm. in Thickness for Conducting Paths.

The specimen is 7.61 meters (25 ft.) in length. Place the specimen between the disk electrodes and the brass plate. Lower the electrodes to make contact with the specimen, and then proceed as described above for paper 0.038 mm. (0.0015 in.) to 0.76 mm. (0.030 in.) in thickness, except that the specimen is passed between the electrodes and the brass plate at a speed not to exceed 11 m. (36 ft.) per minute. The voltage between the plate and the electrodes should be 100 volts per mil thickness of the specimen.

TENTATIVE METHODS OF TESTING ELECTRICAL INSULATING MATERIALS FOR POWER FACTOR AND DIELECTRIC CONSTANT[1]

A.S.T.M. Designation: D 150 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1922; Revised, 1923, 1927, 1931, 1932, 1934, 1935, 1936.

Scope

1. These methods provide for the determination of the power factor and dielectric constant of solid and fluid electrical insulating materials at frequencies from 25 cycles to 1 megacycle per second.

Definitions

Definitions

2. *Dielectric Constant.*—The dielectric constant of a dielectric material is that property which determines the electrostatic energy stored in the material per unit volume per unit potential gradient. For the purposes of these methods the dielectric constant is the ratio of the equivalent parallel capacitance of a capacitor in which the material is the dielectric, measured at the specified frequency, to the capacitance of the same capacitor with a vacuum as the dielectric.

Note.—The dielectric constant of air under normal conditions may be considered equal to that of a vacuum.

3. *Dielectric Phase Angle.*—The dielectric phase angle is the angular difference in phase between the sinusoidal voltage applied to the dielectric and the component of the resulting current which has the same frequency as the applied voltage.

4. *Dielectric Loss Angle.*[2]—The dielectric loss angle is the difference between ninety electrical degrees (90 deg.) and the dielectric phase angle.

5. *Dielectric Power Factor.*—The dielectric power factor of a material is taken as the cosine of the dielectric phase angle or the sine of the dielectric loss angle.

---

[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-9 on Electrical Insulating Materials.

[2] The terms "dielectric phase defect angle" and "dielectric phase difference," with others, have been used in technical literature for this quantity.

NOTE.—When the cotangent of the phase angle is smaller than 0.1, the cosine and the cotangent differ by less than 0.0005 and the power factor may be considered equal to the cotangent of the phase angle or the tangent of the loss angle. When the measured cotangent proves to be larger than 0.1, the correction to be applied to the observed value to secure the power factor may be obtained from the curve of Appendix I, or the corresponding cosine may be taken from trigonometric tables.

6. *Dielectric Loss Factor.*—The dielectric loss factor of a material is the product of its dielectric constant and the tangent of its loss angle.

THEORY OF TEST

Parallel Notation

7. Any insulating material between two electrodes constitutes a capacitor. Such a physical capacitor may be represented by a "pure" capacitance, C_p (loss angle = 0), and a resistance, R_p, in parallel, as shown in Fig. 1. The resistance, R_p, is called the equivalent parallel resistance and the capacitance, C_p, is called the equivalent parallel capacitance. For sine-wave voltage and current the vector relations are as shown in Fig. 2. For this notation the power factor is as follows:

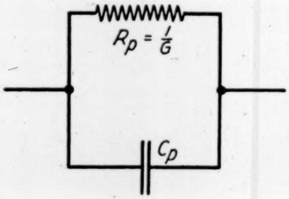


FIG. 1.—Equivalent Parallel Circuit.

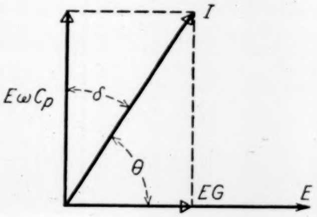


FIG. 2.—Vector Diagram for Equivalent Parallel Circuit.

$$\text{Power factor} = \cos\theta = \sin\delta = \sin\tan^{-1}\frac{1}{\omega C_p R_p} = \sin\tan^{-1}\frac{G}{\omega C_p}$$

where C_p = the capacitance in farads,
R_p = the resistance in ohms,
G = the conductance in mhos, and
ω = 2π times the frequency in cycles per second.

As explained in the Note to Section 5, when $\tan\delta$ is less than 0.1, the error is less than 0.0005 if power factor is taken as $\frac{1}{\omega C_p R_p}$ or $\frac{G}{\omega C_p}$.

Series Notation

8. A physical capacitor may also be represented by a "pure" capacitance, C_s, and a resistance, R_s, in series as shown in Fig. 3. The resistance, R_s, is called the equivalent series resistance and the capacitance, C_s, is called the equivalent series capacitance of the capacitor. For sine-wave voltage and current, the vector relations are as shown in Fig. 4.

The power factor is as follows:

$$\text{Power factor} = \cos\theta = \sin\delta = \sin\tan^{-1}\omega C_s R_s$$

where C_s = the capacitance in farads,
R_s = the resistance in ohms, and
ω = 2π times the frequency in cycles per second.

As explained in the Note to Section 5, for small power factors:

$$\text{Power factor} = \omega C_s R_s$$

Equivalency of Notation

9. The equivalent parallel capacitance and the equivalent series capacitance of a given physical capacitor are not identical, the difference being dependent on the phase angle. If capacitance has been determined as a series capacitor, the equivalent parallel capacitance may be calculated from the following relation:

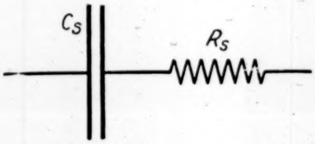


FIG. 3.—Equivalent Series Circuit.

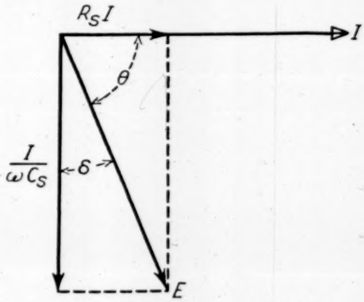


FIG. 4.—Vector Diagram for Equivalent Series Circuit.

$$C_p = \frac{C_s}{1 + \tan^2\delta} = C_s \cos^2\delta$$

The two capacitances are alike within 1.0 per cent unless tan δ exceeds 0.10.

Dielectric Constant

10. (*a*) With a capacitor formed as shown in Fig. 5, with only the opposing surfaces of the two metallic electrodes separated by the dielectric material under test, the total capacitance, C_x, measured between the electrodes will be the sum of the following:

C_p, the "equivalent parallel capacitance" of Section 7, represented in Fig. 5 by the parallel flux lines in the dielectric material between the electrodes,

C_e, the edge correction, represented by the curving flux lines in air, from one electrode to the other, and

C_g, the stray capacitance, represented by the flux lines in air passing from the "high" electrode to space and to earth.

(*b*) When the dielectric material under test is replaced by air (vacuum), the electrodes' spacing and alignment remaining unchanged, and with C_e and C_g remaining presumably unaltered, the equivalent parallel capacitance, C_p, will become the "inter-electrode capacitance," C_a; and by the definition in Section 2, the dielectric constant, K, is given by the following equation:

$$K = \frac{C_p}{C_a} = \frac{C_x - C_e - C_g}{C_a}$$

(*c*) Use of a guard ring (see Fig. 6) makes it possible to exclude the edge correction, C_e, from the measured capacitance, C_x; and a shield about the guarded electrode (and usually the "high" electrode also) can be used to eliminate the stray capacitance, C_g, from the measured capacitance. (See Section 25 on Shielding.) Under these conditions, attainable in the bridges described in Sections 26 to 30, C_x becomes simply C_p, and

$$K = \frac{C_x}{C_a} = \frac{C_p}{C_a}.$$

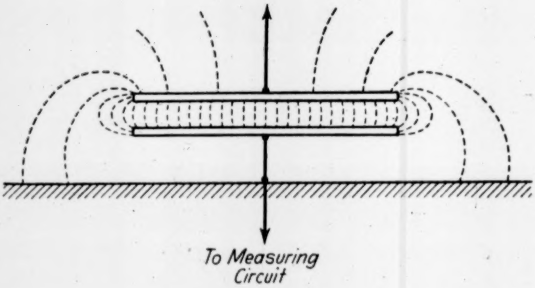


FIG. 5.—Simple Capacitor Circuit.

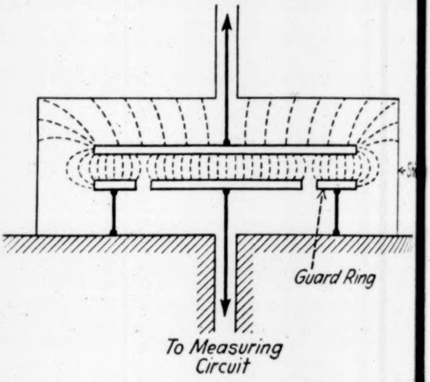


FIG. 6.—Capacitor With Guard Ring and Sh

Formulas for the Inter-Electrode Capacitance, C_a

11. The following formulas are useful for the calculation of the inter-electrode capacitance, C_a, with air (vacuum) as the dielectric:

where A = the area of flat plates,
D = the diameter of flat circular plates,
D_1 = the inside diameter of tube of dielectric material,
D_2 = the outside diameter of tube of dielectric material,
$D_m = \frac{D_1 + D_2}{2}$ = average diameter of tube,
t = the thickness of sheet, layer, film or tube-wall of dielectric material,
L = the length of the cylindrical electrode, and
log = the logarithm of a number to the base 10 (Briggs' logarithm).

(*a*) *For flat opposing parallel plates:*

$$C_a = 0.08854 \frac{A}{t} \text{ micro-microfarads, when dimensions are in centimeters.}$$

$$C_a = 0.2249 \frac{A}{t} \text{ micro-microfarads, when dimensions are in inches.}$$

(*b*) *For flat opposing parallel circular plates:*

$$C_a = 0.06954 \frac{D^2}{t} \text{ micro-microfarads, when dimensions are in centimeters.}$$

$$C_a = 0.1766 \frac{D^2}{t} \text{ micro-microfarads, when dimensions are in inches.}$$

(*c*) *For coaxial cylindrical electrodes:*

$$C_a = \frac{0.2416\, L}{\log \left(\frac{D_2}{D_1}\right)} \text{ micro-microfarads, when dimensions are in centimeters.}$$

$$C_a = \frac{0.6137\, L}{\log \left(\frac{D_2}{D_1}\right)} \text{ micro-microfarads, when dimensions are in inches.}$$

(*d*) *For coaxial cylindrical electrodes:*

(Approximate formula, accurate to 0.1 per cent unless t/D_m is greater than $\frac{1}{3}$.)

$$C_a = 0.2782\, L \left[\frac{D_m}{t}\right] \left(1 - \frac{1}{3}\left[\frac{t}{D_m}\right]^2\right), \text{ micro-microfarads, when dimensions are in centimeters.}$$

$$C_a = 0.7065\, L \left[\frac{D_m}{t}\right] \left(1 - \frac{1}{3}\left[\frac{t}{D_m}\right]^2\right), \text{ micro-microfarads, when dimensions are in inches.}$$

(*e*) *Guards:*

When a guard ring is used with a circular or a rectangular plate, or guard tubes with a cylindrical electrode, the effective area of the electrode is increased by one-half the area of the space between the guard and the electrode. Thus for circular plates, the D of Paragraph (*b*), should be replaced by $(D + w)$, and the L of Paragraphs (*c*) and (*d*) by $(L + w)$, where w = the width of gap between electrode and guard.

The width of a guard ring or the lengths of the guard tubes should be not less than five times the thickness of the dielectric.

Edge Correction, C_e[1]

12. (*a*) *Circular Plate Electrodes.*—If a guard ring is not used the edge correction is larger than 5 per cent when the diameter of the circular plate electrodes is less than 50 to 60 times the thickness of the specimen. Figure 7 gives percentage corrections to be applied to the calculated interelectrode capacitance, C_a, for circular plates, for various ratios of specimen

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[1] See extended treatment of this subject in paper by Harvey L. Curtis and Arnold H. Scott, "Edge Correction in the Determination of Dielectric Constant," *Proceedings*, Am. Soc. Testing Mats., Vol. 36, Part II (1936).

thickness to plate diameter, t/D. The curves also show the effect of the thickness of the electrode plates, designated by b, for several values of b/t. These curves are for the condition where the electrodes are of the same diameter as the specimen disk, that is, both upper and lower electrodes come flush with the edge of the specimen. The curves may be used either for foil electrodes or for mercury electrodes when the mercury is confined by rings of the same diameter as the specimen.

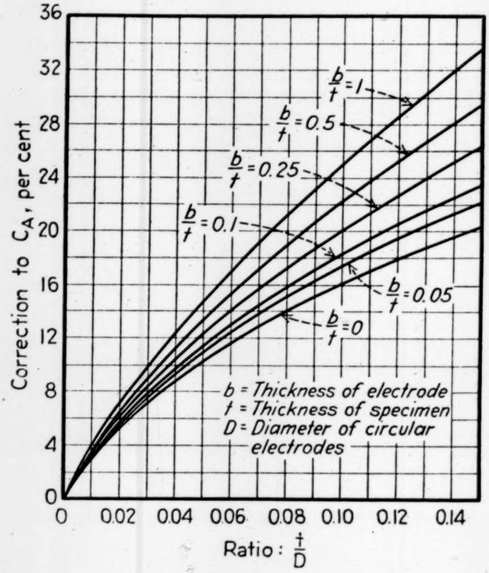

FIG. 7.—Curves for Edge Correction for Circular Plates of Various Thicknesses (Electrodes of Same Diameter as Specimen).

Calculated from Kirchhoff's equation for inter-electrode capacitance:

$$C_1 = \frac{R^2}{4t} + \frac{R}{4\pi}\left(\log_e\left[\frac{16\pi R(t+b)}{t^2}\right] + \frac{b}{t}\cdot\log_e\left[\frac{t+b}{b}\right] - 3\right)$$

where R = the radius of circular electrodes,
b = the thickness of electrodes, and
t = the thickness of dielectric.

All dimensions in centimeters. Capacitance in statfarads; to convert to micro-microfarads multiply by 1.113

NOTE.—*Example:*

Diameter of specimen, $D = 5.0$ in.
Thickness of specimen, $t = 0.375$ in.
Thickness of foil plates, $b = 0.015$ in.
Ratio, $t/D = 0.075$
Ratio, $b/t = 0.04$
Correction factor = 14.2 per cent
Inter-electrode capacitance, $C_a = 11.78$ μμ F.
Edge correction, $C_e = 1.67$ μμ F.

With mercury electrodes, suppose:
Height of confining rings, $b = 0.125$ in.
Ratio, $b/t = 0.33$
Correction factor = 17.0 per cent
Edge correction, $C_e = 2.00$ μμ F.

(*b*) *Rectangular Plate Electrodes.*—No satisfactory expressions have been published for the edge correction for rectangular plate electrodes with lengths and widths of the same order of magnitude. If unguarded rectangular electrodes must be used and the edge correction appears important, then the correction curves of Fig. 7 may be employed for an approximation, with D representing the diameter of a circle having the same perimeter as the rectangular electrodes.

(*c*) *Electrodes Smaller than the Specimen.*—In this case part of the fringing flux is in air and part passes through the specimen. The edge correction will vary both with the relative size of the specimen and with its dielectric constant. Figure 8 shows curves for edge correction, experimentally determined,[1] for various values of dielectric constant, for specimens 6.0 in. square, and for two particular arrangements of electrodes, (*1*) both electrodes circular, 4.5 in. in diameter, of thin metal foil, and (*2*) lower electrode a square 6.0 in. on a side, upper electrode circular, 4.5 in. in diameter, both of thin metal foil. A knowledge of at least the approximate value of the dielectric constant, K, is required for the use of Fig. 8. This can always be obtained by making a preliminary calculation, neglecting C_e in the formula of Section 10. These curves will not serve for specimens and electrodes of other sizes and shapes.

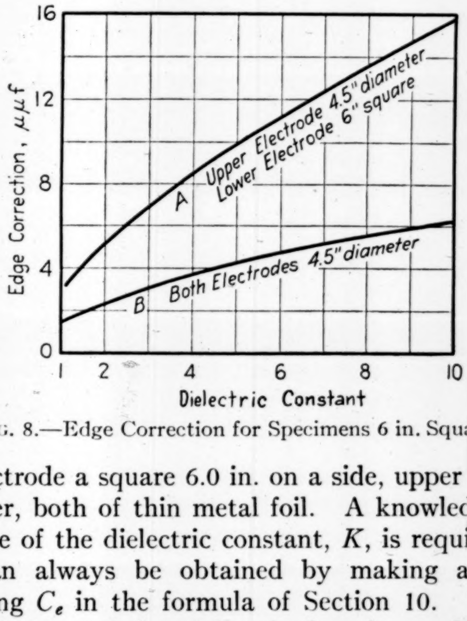

FIG. 8.—Edge Correction for Specimens 6 in. Square.

(*d*) *Cylindrical Electrodes.*—No formulas are available for edge correction for concentric cylindrical electrodes. Where the ratio t/D_m is less than say $\frac{1}{6}$ and where the tube specimen extends beyond the electrodes at all times by at least five times the wall thickness, the edge correction may be eliminated from the determination by measuring the capacitance of the test specimen with two lengths of electrodes, due care being exercised, of course, to keep the electrodes of equal lengths in each case and accurately opposite each other. For maximum accuracy of determination of the dielectric constant, K, L' should be about one-half of L. If C_p and C'_p are the measured capacitances corresponding to the lengths L and L' of the cylindrical electrodes, and with t/D_m less than $\frac{1}{6}$, the following expressions will give a value of dielectric constant with an error smaller than 1 per cent. See also Section 11 (*c*) and (*d*).

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[1] From "Electrode Effects," E. T. Hoch, Bell System *Technical Journal*, Vol. 5, p. 571 (1926).

$$K = 3.60\,\frac{(C_p - C'_p)t}{D_m\,(L - L')}, \text{ when dimensions are in centimeters.}$$

$$K = 1.415\,\frac{(C_p - C'_p)t}{D_m\,(L - L')}, \text{ when dimensions are in inches.}$$

When the method of measurement permits the use of a guard sleeve the edge correction may be eliminated.

Stray Capacitance, C_g

13. The correction curves of Fig. 7 apply to a capacitor with one electrode at earth potential while the electrostatic flux from the "high" electrode passes to earth (or source) without entering the measuring circuit. This limitation can be satisfied when using the screened bridge methods shown in Figs. 9, 10, 11, 12 and 14. In the Resonant Circuit Substitution Method of Section 31, the electrostatic flux from the ungrounded plate represents an additional capacitance which is effective in influencing the frequency of oscillation and must, therefore, be considered. For a circular electrode this stray capacitance, C_g, may be calculated from the following:

$C_g = 0.177\ D$, micro-microfarads, when dimensions are in centimeters.
$C_g = 0.449\ D$, micro-microfarads, when dimensions are in inches.

where C_g = the capacitance to earth (or space) of the ungrounded electrode, and
D = the diameter of the circular, ungrounded electrode.

NOTE.—*Example:* Suppose a capacitor, formed with 5-in. foil electrodes as above on a sample of insulating material, showed a measured capacitance in the resonant-circuit substitution method of the following:

$$\begin{aligned} C_p &= 50.00\ \mu\mu\ F. \\ C_g &= 2.25\ \mu\mu\ F. \\ C_e &= 1.67\ \mu\mu\ F. \\ C_a &= 11.78\ \mu\mu\ F. \end{aligned}$$

$$K = \frac{C_p - C_e - C_g}{C_a} = 3.91$$

Dielectric Loss Factor

14. The power loss per unit volume of insulating material at a stated frequency, voltage gradient, and temperature is proportional to the product of its dielectric constant and the tangent of its loss angle. It is for this reason that dielectric loss factor has been defined in Section 6 as follows:

$$\text{Loss Factor} = K \times \tan\delta, \quad \text{or} = K \times \cot\theta.$$

TEST SPECIMENS

15. Methods of test have been standardized for a number of kinds of insulating materials by the American Society for Testing Materials. These A.S.T.M. Standards should be consulted for special requirements as to test specimens, such as preparation, size, treatment, etc.

(*a*) *Sheets and Plates.*—For testing sheet materials and molded or ceramic materials in plate form, the test specimen shall be, preferably, either a disk 6 in. (15.24 cm.) in diameter, or a square plate 6 in. (15.24 cm.) on a side. Preferably, the thickness shall be not less than 0.1 in. (0.254 cm.) nor more than 0.3 in. (0.762 cm.). The thickness shall be uniform to ±5 per cent, and the surface shall be smooth and free from irregularities. Other thicknesses may be used where it is desired to test materials of the various thicknesses in commercial use. In any case, the capacitance of the specimen shall be, preferably, not less than 100 micro-microfarads. Use of smaller specimens increases the effects of stray capacitances and decreases the precision of measurement.

(*b*) *Films.*—For testing films of insulating varnish, lacquer, or paints, the test specimen shall be prepared as specified for the dielectric strength tests on copper base in Appendix II to the Tentative Methods of Testing Varnishes Used for Electrical Insulation (A.S.T.M. Designation: D 115 - 36 T) of the American Society for Testing Materials.[1] The copper or brass plate shall be one capacitor plate, and tin-foil the other. Both varnish films may be tested individually.

(*c*) *Tubes.*—For testing rolled or molded laminated tubes or ceramic tubes, the test specimen shall have the diameter and wall thickness of the material it represents, and shall be of sufficient length to provide a capacitance of not less than 100 micro-microfarads. The thickness shall be uniform to ±5 per cent, and the surfaces shall be smooth and free from irregularities.

(*d*) *Liquids.*—The liquid shall be tested in a suitable test cell in which the ratio of surface to thickness of liquid layer is sufficient to give a capacitance of not less than 100 micro-microfarads. One form of test cell that has been found satisfactory, except for extra high quality oils, is shown in Appendix IV to the Tentative Methods of Testing Solid Filling and Treating Compounds Used for Electrical Insulation (A.S.T.M. Designation: D 176 - 36 T) of the American Society for Testing Materials.[2]

16. *Conditioning.*—The dielectric properties of most insulating materials are affected by temperature, humidity, pressure, exposure to air, etc. Hence, considerable importance may attach not only to the condition of the material at the time of measurement but also to the treatment it has

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[1] See p. 1058.

[2] See p. 1019.

undergone in the immediate past. Reference should be made to any standard for the material under test to learn what conditioning treatment has been specified. If such specifications have not been formulated the conditioning treatment to be given prior to measurement shall be agreed upon by the interested parties. Air temperatures in conditioning chambers with volumes of say 4 cu. m. (say 140 cu. ft.) may readily be maintained constant within ± 1 C. (± 1.8 F.). A satisfactory method of maintaining constant humidity in a chamber is given in Section 13 of the Standard Methods of Test for Resistivity of Insulating Materials (A.S.T.M. Designation: D 257) of the American Society for Testing Materials.[1] Whenever feasible, specimens should remain in the conditioning chamber during the measurements; the test leads must be suitably shielded (see Section 25).

ELECTRODES

17. (*a*) *Sheets and Plates.*—Where the method of measurement will permit, a guard ring shall be employed. In this case the unguarded electrode shall be a foil disk about 6 in. in diameter while the guarded electrode shall be a foil disk about 4.5 in. in diameter cut from a 6-in. disk leaving as narrow a space between guard ring and guarded electrode as is mechanically feasible. But in any case the radial width of the guard ring shall not be less than five times the thickness of the specimen. A very thin coating of petrolatum shall be used as an adhesive for foil electrodes; such electrodes shall be applied under a smoothing pressure sufficient to eliminate all wrinkles; they shall be accurately centered with respect to each other and at least approximately centered with respect to the specimen. When measurements are to be made at frequencies of the order of megacycles per second it may be necessary to press the electrodes against the specimen with a pressure of several hundred pounds per square inch in order to obtain correct values.

Mercury pool electrodes and guard ring may be employed but great care shall be exercised to prevent inclusion of small air bubbles between the mercury pool and the under surface of the specimen floating on the pool.

When the specimen is smaller than the recommended size and a guard ring cannot be employed, the electrodes shall cover the specimens to the edges. Care must be exercised that the leakage resistance over the edges between electrodes is not lowered by handling or by the application of the electrodes.

It is to be noted that no edge correction data are available for the case where unguarded electrodes do not come to the edge of the specimen, except those experimentally determined for the particular sizes of electrodes and specimens given in Section 12 (*c*) and Fig. 8.

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 1203.

(*b*) *Films.*—For testing materials of thickness less than 0.1 in. (0.254 cm.), such as thin-sheet insulating materials and films of insulating varnish and lacquer, the electrode area may be adjusted to give any convenient capacitance above 100 micro-microfarads. For films less than about 0.07 in. in thickness the error in dielectric constant incurred by omitting the edge correction will usually be less than 5 per cent. A guard ring, constructed as specified in Paragraph (*a*), should be used when feasible.

(*c*) *Tubes.*—The outer electrode shall consist of tin foil or lead foil. The inner electrode shall consist either of tin foil or lead foil, or of mercury. When guard rings cannot be employed and the edge correction is to be eliminated by measurements with two lengths of electrodes, the electrodes shall be of the same length, accurately centered with respect to each other, and approximately centered with respect to the specimen. The tube shall extend beyond the larger electrodes by at least five times the wall thickness; the electrodes need be reduced in length from one end only in order to form the shorter electrodes.

A very thin coating of petrolatum shall be used as an adhesive for foil electrodes. A cork or a wax plug provides means for holding mercury in the tube.

Wherever the method of measurement permits, guard rings of foil at both ends of the outer electrode shall be employed.

(*d*) *Liquids.*—Some form of cell which will hold the liquid between suitable electrodes is usually employed. One satisfactory type of cell for this purpose has been referred to in Section 15 (*d*); if the insulation at the bottom of this cell is perforated the electrode assembly may be used as an immersion unit, which is often convenient. Guard rings (or cylinders) should be used wherever the method of measurement will permit. The electrodes may be either coaxial cylinders or parallel plates. The dimensions of the cell shall be such as to yield any convenient capacitance larger than 100 micro-microfarads (with the test liquid in place). The mechanical construction shall be such that the relative positions of the electrodes are not altered in the operation of filling the cell with the test liquid, or in bringing the cell and its contents to the desired test temperature. Also, the construction of the cell must be such that in the cleaning operation all traces of a former specimen can be completely removed. Any insulation used in the construction of the cell shall be of a material which will not contaminate the test specimen; in the case of a liquid with very low power factor it is desirable to use a cell in which this insulation does not come into contact with the specimen. The electrodes shall not react with the specimen to alter its power factor.

Measurements at Other than Room Temperature

18. (*a*) It is frequently desirable to measure the losses in materials at temperatures other than room temperature. In order to do this the apparatus for holding the specimen may be placed within an oven for elevated temperatures and a refrigerator for lower temperatures, and measurements shall be made while the specimen is in the conditioned atmosphere. In either case the temperature shall be controlled. Proper care shall be exercised in carrying the leads from the bridge to the specimen so that they are properly insulated and shielded.

(*b*) It is desirable to measure the humidity at all temperatures. Humidity may cause changes as large or larger than those caused by temperature. The percentage relative humidity and the period of time during which the specimen has been exposed to that humidity shall be reported

PROCEDURE

Methods

19. A bridge circuit shall be used for the measurement of power factor and dielectric constant of insulating materials at all frequencies up to 100 kilocycles. From 100 kilocycles up to 1 megacycle either a suitable bridge method or the resonant-circuit substitution method may be employed. Above 1 megacycle the latter method is preferred.

Power Source

20. The generating circuit may be any suitable source which can furnish sufficient current for the specified precision of measurement or voltage gradient in the dielectric. The wave form of the voltage applied to the bridge or existing at the terminals of the resonant circuit shall be approximately of sine-curve shape, having a distortion factor[1] of not more than 5 per cent.

Detector

21. Any suitable detector may be employed which has the specified sensitivity and which responds only to the frequency of the fundamental component of the voltage applied to the bridge or existing at two terminals of the resonant circuit. These conditions apply also to amplifying means used in conjunction with the detectors and are imposed in conformity with the definition of dielectric phase angle given in Section 3. A selected list of references to detectors in technical literature is given in Appendix III of these methods.

Accuracy and Sensitivity

22. These methods contemplate an accuracy of determination of dielectric constant of ±5 per cent, and an accuracy of determination of

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[1] The distortion factor of a voltage wave is the ratio of the effective value of the residue after the elimination of the fundamental to the effective value of the original wave. Am. Inst. Electrical Engrs., "Electrical Definitions," paragraph 10. 95. 430.

power factor of ±5 per cent but in no case to closer than 0.0001. These accuracies are conditional upon the precision of measurement of the dimensions of the specimen, care in application of electrodes, disposition of the component parts of the test circuits and calibration of standard resistors and capacitors. The detector used shall have a sensitivity permitting determinations with an apparent accuracy at least twice that specified above.

General Method of Measurement

23. (*a*) The diagrams of four of the test circuits (Figs. 9, 11, 12 and 15) in the following sections represent the test capacitor, C_x, connected in parallel with a variable precision air capacitor, C_2. The procedure contemplated in these cases is first to secure a reading with the connections as shown, and then to disconnect and "ground" the "high" plate of the test capacitor, C_x; following which the circuit is restored by changing C_2 and varying the means for changing power factor, the rest of the bridge or resonant circuit remaining unchanged. The effects of various residual errors in other parts of the circuit are thereby minimized. The equivalent parallel capacitance, C_p, of the test specimen will then be calculated from the change in reading of C_2.

(*b*) Frequently, a variable precision air capacitor is not available which can withstand the voltage to be applied to C_x; this is usually the case when the High-Voltage Schering Bridge of Fig. 10 or the Transformer Bridge of Fig. 14 is required. Recourse must then be had to the direct comparison of C_x with the comparison capacitor C_1. In such cases, residual errors in the bridge should be minimized or determined by a calibration under conditions as closely similar as possible to those existing when the test specimen was being measured.

APPARATUS

Bridges

24. Five bridge arrangements are shown in Figs. 9, 10, 11, 12, 13 and 14. These bridges have been found satisfactory for the purposes indicated but this is not to be taken as excluding other types of bridges of equal precision and convenience. The formulas for the equivalent parallel capacitance of the specimen C_p, and for the tangent of its loss angle, tan δ_p, are given in a simplified form which is sufficiently accurate when the loss angles of the various bridge arms are small; the equations are furnished both for the change-of-standard method and for the direct comparison of capacitors without use of the change-of-standard method. When the loss angles of the bridge arms are greater than about 6 deg. (tan δ = 0.1) or where a precision better than 1 per cent is desired, more elaborate formulas are required. These are given for each bridge in Appendix II.

Shielding

25. (*a*) Extensive shielding has been indicated on each bridge as being much the safest procedure when measuring capacitance to $1\mu\mu F$ or better. Shields for all air-capacitors are shown connected to the "low-voltage" plate since that is the usual condition under which most variable air-capacitors are constructed and calibrated. However, when "three-terminal capacitors" are available, the shield of such capacitors should be connected to the general shielding system. The test capacitor's shield and guard-ring (when one is employed) are connected to the general shielding system as are also the shields for the resistance units. Leads from the supply or insulating transformer to the bridge, and all bridge leads from terminals *A* and *C* are shielded. Except in the case of the High-Voltage Schering Bridge (see Fig. 10), the shielding system is grounded. With these precautions it is usually unnecessary to shield the detector circuit. However, when a vacuum-tube amplifier is employed or high precision is sought, it is best to shield the detector circuit also, and all low-voltage leads as indicated in Figs. 10 and 11.

(*b*) The "Wagner ground" connection is indicated in each bridge (except the High-Voltage Schering Bridge) as a method to be used to bring detector potential to that of earth. In general, the resistors of the Wagner ground should be of the same order of resistance as the ratio arms, R_3 and R_4, in order not to load the input transformer more heavily than necessary. It must be possible to adjust the ratio of these resistors with the same precision as the main bridge and for this purpose a low-resistance slide-wire is provided as shown in the figures. The capacitors required for the Wagner ground should have such a range that in their (opposite) extreme positions the difference in capacitance between them will cover any unbalance of stray capacitances between the shields and the measuring circuit. A three-plate type of capacitor is useful for this purpose. A shield between primary and secondary coils of the input transformer should be provided and connected as indicated. A grounded shield, preferably in the form of a metal-screen cabinet or room, enveloping the entire bridge set-up is desirable, especially at frequencies in the broadcast range. This shield and the shield shown about the specimen condenser, C_x, should not approach the bridge elements so closely as to increase unduly the capacitance to ground.

(*c*) The bridge diagrams indicate one side of the detector, *G*, permanently connected at bridge terminal *D*, between the ratio arms, with a key provided to connect the other side of *G* alternately to the bridge terminal *B* and to the shielding system. In proceeding with the test the bridge and Wagner ground are balanced alternately. This procedure is not laborious and is satisfactory for all but the most precise work. For work of the highest precision it becomes essential to keep the detector constantly at ground potential. In that case, one side of *G* is permanently attached to the shielding system while the other side is alternately connected to the bridge terminals D and B with successive balancings of the Wagner ground and of the bridge, respectively. Under this procedure it is imperative that the balance of the Wagner ground be made as precisely and completely as the balance of the bridge proper.

Conjugate Schering Bridge

26. (*a*) See Fig. 9. This bridge is applicable for all frequencies from 25 cycles per second up to 1 megacycle per second. R_3 and R_4 should be identical resistor units of a type practically free from capacitance, with resistance of the order of 10,000 ohms for use at frequencies of the order of 10 kilocycles per second and less; 1000-ohm units may be used for frequencies of the order of 1 megacycle per second if the capacity of the source warrants. The air capacitor, C_3, is used to produce a positive reading for C_4 when C_2 alone is in circuit; it should be no larger than is necessary for this purpose.

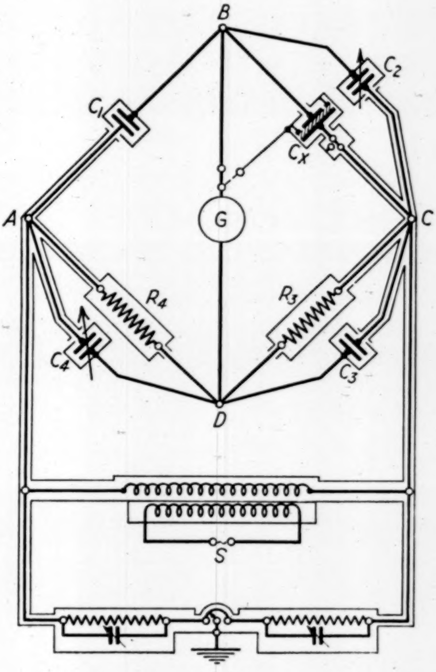

FIG. 9.—Conjugate Schering Bridge (Simple Shielding).

(*b*) With the test condenser, C_x, in place as indicated in Fig. 9, its switch is closed and the bridge is balanced by successive adjustments of C_2 and C_4, alternating with adjustments of the Wagner ground. When G

shows complete balance with the key at B in either position the readings of C_4 and C_2 shall be recorded. Then the switch of C_x shall be turned to the shield and new balance values for C_4 and C_2 obtained. From the four values thus secured the equivalent parallel capacitance and the loss angle of the specimen capacitor C_x, may be calculated from the following approximation formulas; see Appendix II for exact formulas:

$$C_p = C_2 - C'_2 \quad \text{Eq. (1)}$$

$$\tan \delta_p = \frac{C_2}{C_2 - C'_2} \times \frac{2\pi f R_4 (C'_4 - C_4)}{10^{12}} \quad \text{Eq. (2)}$$

where C_p = the equivalent parallel capacitance of the test capacitor formed from the test specimen, in micro-microfarads,

C'_2 = the capacitance of the variable air capacitor in parallel with C_x, when the latter is in circuit, in micro-microfarads,

C_2 = the capacitance of the variable air capacitor when balance has been restored after the test capacitor C_x has been disconnected from the circuit, in micro-microfarads,

C'_4 = the capacitance of the capacitor C_4 at balance when C_x is in circuit, in micro-microfarads,

C_4 = the capacitance of the capacitor C_4 at balance when C_x is out of circuit, in micro-microfarads, and

f = the frequency, in cycles per second.

(*c*) If the change-of-standard method is not used, dependence may be placed on a single set of observations in a direct comparison of C_x with C_1, the corrections to be applied to the observations having been determined by other means. In this case C_2 shall be removed and C_1 shall be a variable standard air-capacitor. At balance, the following relations hold approximately, and the calculations may be made from these formulas; see Appendix II for exact formulas:

$$C_p = C_1 \frac{R_4}{R_3} \quad \text{Eq. (3)}$$

$$\tan \delta_p = \frac{2\pi f}{10^{12}} \times (R_4 C_4 - R_3 C_3) \quad \text{Eq. (4)}$$

where R_3 and R_4 = the resistances of the ratio arms, in ohms,

C_3 and C_4 = the corresponding capacitances at balance of the capacitors across R_3 and R_4, respectively, in micro-microfarads, and

C_1 = the capacitance of the variable standard capacitor at balance, in micro-microfarads.

High Voltage Schering Bridge

27. (*a*) See Fig. 10. This bridge is applicable for all frequencies from 25 cycles per second up to 1 megacycle per second where the voltage required across the specimen capacitor is in excess of about 100 v. R_4 shall be a fixed resistance practically free from capacitance, of such magnitude as to give a fall of potential across it sufficient to achieve the specified detector sensitivity. R_3 likewise shall be practically free from capacitance; it shall be variable in steps at least as small as 0.1 per cent of its value at balance, not for the precision required but in order that balance may be completed; for measurements of small power factors ability to change R_3 in steps as small as 0.01 per cent of its value will be convenient. The air capacitor, C_1, shall be insulated to withstand the voltage to be applied to the test capacitor C_x without setting up ionization losses. Preferably, C_1 shall be adjusted to the order of capacitance of C_x. The air capacitor C_3 may be of the order of 50 micro-microfarads.

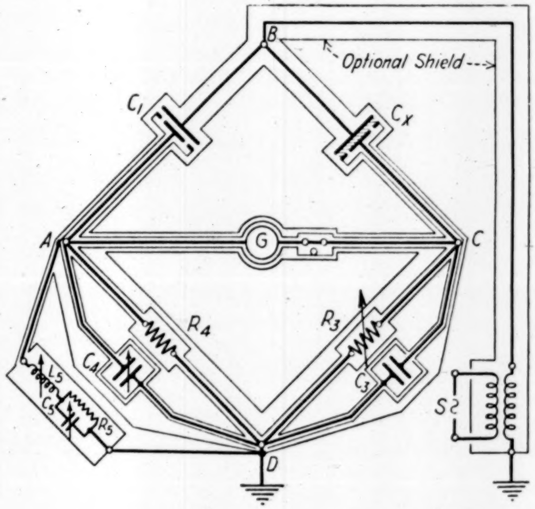

FIG. 10.—High Voltage Schering Bridge (Complete Shielding).

(*b*) Balance shall be obtained with the switch at *G* connected successively to bridge terminal *C* and to the shields. Unless the power factor of the stray capacitance to the shields is higher than the power factor of C_x it will be necessary to use the inductometer, L_5, in series with the resistor, R_5, rather than the parallel capacitor, C_5, in order to balance screen potential. However, it is seldom necessary to balance the inner shields for phase.[1] Also if the capacitance to the shields is small, R_5 may be inconveniently large; in that case a suitable capacitor, with insulation capable of withstanding circuit voltage, may be connected from terminal *B* to the inner shield system.

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[1] W. B. Kouwenhoven and Alfredo Banos, Jr., "High Sensitivity Power Factor Bridge," *Transactions*, Am. Inst. Electrical Engrs., Vol. 51, p. 202 (1932).

(*c*) When balance is complete the equivalent parallel capacitance of C_x and its loss angle may be calculated from Eq. (3) and Eq. (4), respectively, as given in Section 26. It is always wise to demonstrate the accuracy of the bridge readings by substituting, at intervals, for C_x, a capacitor of known capacitance and loss angle.

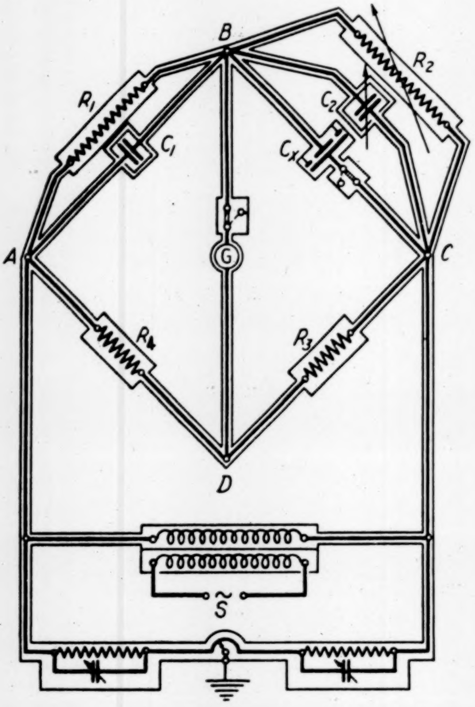

FIG. 11.—Parallel Resistance Bridge (Complete Shielding).

Parallel Resistance Bridge

28. (*a*) See Fig. 11. This bridge is applicable for all frequencies from 25 cycles per second up to 1 megacycle per second. R_3 and R_4 shall be identical resistor units of a type practically free from capacitance with resistance of the order of 10,000 ohms for use at frequencies of the order of 100 kilocycles per second and less; 1000-ohm units may be used for frequencies of the order of 1 megacycle per second if the capacity of the source warrants. The resistor R_1 may be a fixed unit, the value of which is suited to the frequency employed in the measurement and to the capacitance and conductance of the specimen; it shall be practically free from capacitance. R_2 shall be variable, with a range up to the value of R_1

employed and the change in its capacitance, if appreciable, must be known as its value is altered to restore balance when the test capacitor C_x has been disconnected.[1] R_2 may be composed with advantage of two parts, one of which is variable in steps of 10,000 ohms while the other part is represented in a four-dial or five-dial resistance box.

(*b*) A balance of both bridge and Wagner ground shall be secured with C_x in circuit, and then with C_x out of circuit. The capacitance and loss angle of C_x may be calculated from the following approximation formulas; see Appendix II for exact formulas:

$$C_p = C_2 - C'_2 \dots\dots\dots\dots \text{Eq. (5)}$$

$$\tan \delta_p = \frac{(R_2 - R'_2) \times 10^{12}}{2\,\pi f R_2\, R'_2\, (C_2 - C'_2)} \dots\dots\dots\dots \text{Eq. (6)}$$

where C_p = the equivalent parallel capacitance of the test capacitor formed from the test specimen, in micro-microfarads,

C'_2 = the capacitance of the variable air capacitor in parallel with C_x when the latter is in circuit, in micro-microfarads,

C_2 = the capacitance of the variable air capacitor when balance has been restored after the test capacitor C_x has been disconnected from the circuit, in micro-microfarads,

R'_2 = the resistance at balance of the resistor in parallel with the capacitor C_2, when C_x is in circuit, in ohms,

R_2 = the resistance at balance of the resistor in parallel with the capacitor C_2, when C_x is out of circuit, in ohms, and

f = the frequency, in cycles per second.

(*c*) If the change-of-standard method is not used dependence shall be placed on a single set of observations in a direct comparison of C_x with C_1, the corrections to be applied to the observations having been determined by other means. In this case, C_2 shall be removed, C_1 is a variable standard air capacitor, and the resistance balance shall be secured by varying R_1. At balance, approximately, the following relation holds and the calculations may be made from these formulas; see Appendix for exact formulas:

$$C_p = C_1 \frac{R_4}{R_3} \dots\dots\dots\dots \text{Eq. (7)}$$

$$\tan \delta_p = \frac{10^{12}}{2\,\pi f}\left(\frac{1}{C_1 R_1} - \frac{1}{C_p R_2}\right) \dots\dots\dots\dots \text{Eq. (8)}$$

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[1] In general, it is desirable to have these resistances at least as large as the reactance of the test condenser; otherwise the bridge loses in sensitivity for the capacitance balance. Also R_2 must be subdivided sufficiently to complete the conductance (power factor) balance. For example: The reactance of 100 $\mu\mu$F. at 100 kilocycles per second is 15,916 ohms. If R_2 is of the order of 10,000 ohms, a power factor difference of 0.0001 corresponds to a change in R_2 of about 0.6 ohm and R_2 should have a dial which permits a setting to at least 1 ohm. If R_2 were of the order of only 1000 ohms, a power factor change of 0.0001 would correspond to a change in R_2 of only 0.006 ohm.

where R_3 and R_4 = the resistances of the ratio arms,
R_1 and R_2 = the resistances in parallel with the capacitors C_1 and C_x, respectively, in ohms, and
C_1 = the capacitance of the variable standard air capacitor at balance, in micro-microfarads.

Series Resistance Bridge

29. (*a*) See Fig. 12. This bridge is applicable for all frequencies from 200 cycles per second up to 1 megacycle per second. R_3 and R_4 shall be identical resistor units, of a type practically free from capacitance, with resistance of the order of 10,000 ohms for use at frequencies of the order of 100 kilocycles per second and less; 1000-ohm units may be used for frequencies of the order of 1 megacycle per second if the capacity of the source warrants. The resistor R_1 shall be practically free from capacitance; it shall be variable up to about 100,000 ohms for frequencies in the order of 200 cycles per second and power factors in the order of 0.02 or smaller; a minimum step of 1 ohm will usually be adequate for this resistance up to frequencies in the order of 100 kilocycles per second. The air capacitor C_3 shall be used to produce a positive reading for R_1 when C_2 alone is in

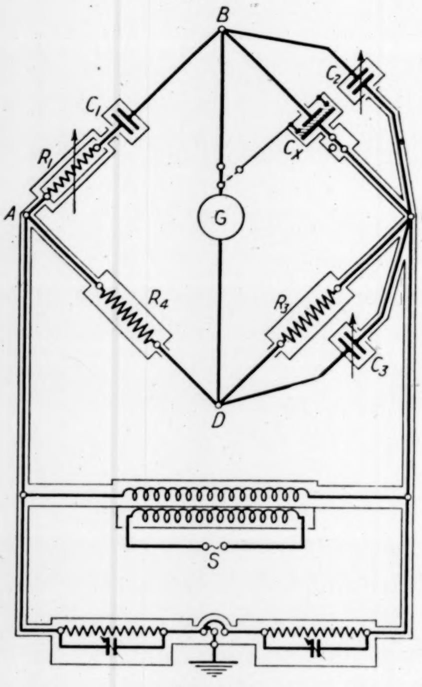

FIG. 12.—Series Resistance Bridge (Simple Shielding).

circuit; it shall be no larger than is necessary for this purpose. The variable resistor, R_1, is in the "high" side of the bridge; it is shown double-shielded; this will tend to fix its capacitance to earth. Special dial knobs may be required to avoid variable stray capacitance to the hand.

(*b*) A balance of both bridge and Wagner ground shall be secured with C_x in circuit and then with C_x out of circuit. The capacitance and loss angle of C_x shall be calculated from the following approximation formulas; see Appendix II for exact formulas:

$$C_p = C_2 - C'_2 \text{..............................Eq. (9)}$$

$$\tan \delta_p = \frac{C_2}{C_2 - C'_2} \times \frac{2\ \pi\ f\ C_1}{10^{12}}\ (R'_1 - R_1) \text{...........Eq. (10)}$$

where C_p = the equivalent parallel capacitance of the test capacitor formed from the test specimen, in micro-microfarads,

C'_2 = the capacitance of the variable air capacitor in parallel with C_x when the latter is in circuit, in micro-microfarads,

C_2 = the capacitance of the variable air capacitor when balance has been restored after the test capacitor C_x has been disconnected from the circuit, in micro-microfarads,

C_1 = the capacitance of the comparison air capacitor, in micro-microfarads,

R'_1 = the resistance in series with the capacitor C_1 at balance when C_x is in circuit, in ohms,

R_1 = the corresponding resistance when C_x is out of circuit, in ohms, and

f = the frequency, in cycles per second.

(*c*) If the change-of-standard method is not used dependence shall be placed on a single set of observations in a direct comparison of C_x with C_1, the corrections to be applied to the observations having been determined by other means. In this case C_2 shall be removed and C_1 shall be a variable standard air capacitor. At balance, approximately, the following relations hold and the calculations may be made from these formulas; see Appendix II for exact formulas:

$$C_p = C_1 \frac{R_4}{R_3} \text{..................................Eq. (11)}$$

$$\tan \delta_p = \frac{2\ \pi\ f}{10^{12}}(C_1R_1 - C_3R_3) \text{.......................Eq. (12)}$$

where R_3 and R_4 = the resistances of the ratio arms, in ohms, and

C_3 = the capacitance of the air capacitor across R_3, in micro-microfarads.

Transformer Bridge[1]

30. See Figs. 13 and 14. This bridge is applicable for all frequencies from 25 cycles per second (or lower) up to 1000 cycles per second (or higher) for which suitable transformers (phase angles not larger than a few minutes) are available. This method is especially recommended for measurements at high voltage gradients in the specimen and where the highest precision is not required but speed in operation is desirable. Complete shielding is secured in this method without the need for a guard balancing circuit. Only one form of the bridge is shown; other forms are equally available. Figure 13 is a diagrammatic representation, in the form used for the preceding bridges. Figure 14 shows the shielding arrangements. E_3, E_4 and E'_4 are transformer secondary coils of which the primary coils are excited from the same source; instantaneous polarities of these coils are indicated.

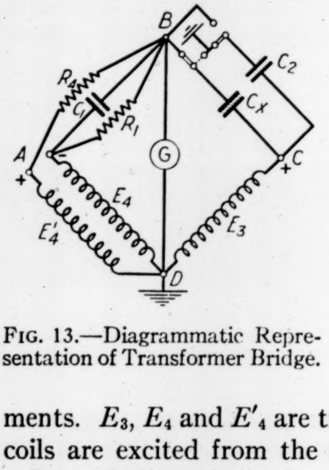

FIG. 13.—Diagrammatic Representation of Transformer Bridge.

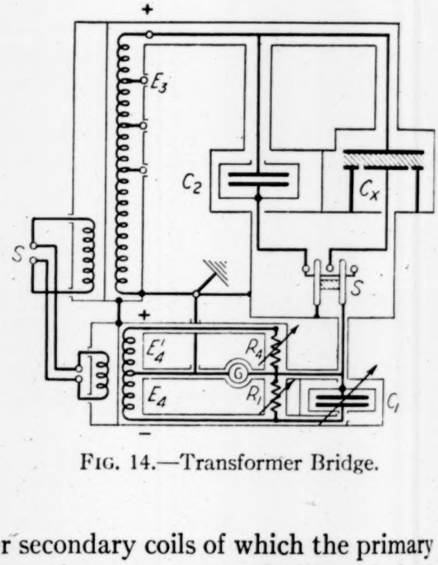

FIG. 14.—Transformer Bridge.

(*a*) *Three-Balance Method, C_2 Variable.*—When the capacitor C_2 is a variable standard air capacitor, insulated to withstand the voltage to be applied to the test capacitor C_x without ionization losses setting in, the balancing shall be performed as follows: There are three steps to the balancing operation. With C_x in circuit and C_2 grounded, R_1 shall be set at 10,000 ohms (100,000 ohms) or any convenient value; balance shall be secured by varying C_1 and R_4. This may be called the preliminary balance. Next C_x shall be grounded while C_2 is put into circuit. Balance shall be secured by varying C_2 and R_4; C_1 shall be left at the "preliminary" setting. At the third balance, the switch S shall be returned to its first position with

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[1] See J. B. McCurley, W. B. Kouwenhoven and P. H. Dike, "The Transformer Bridge," *Proceedings* Am. Soc. Testing Mats., Vol. 35, Part II, p. 734 (1935).

C_x in circuit and C_2 grounded; balance shall be secured only by a change in R_1. Then, with only a very small degree of approximation (see Appendix II):

$$C_p = C_2 \text{.......................................} \text{Eq. (13)}$$

$$\tan \delta_p = \frac{(R'_1 - R'''_1) \times 10^{12}}{2\,\pi\, f\, C'_1 R'_1 R'''_1} \text{......................} \text{Eq. (14)}$$

where C_p = the equivalent parallel capacitance of the test capacitor formed from the test specimen, in micro-microfarads.

C_2 = the capacitance of the variable standard air capacitor, in the second balance, in micro-microfarads,

C'_1 = the capacitance of the "low-voltage" capacitor, unchanged after the first balance, in micro-microfarads,

R'_1 = the resistance of the "negative" resistor, as selected for the first balance, in ohms,

R'''_1 = the resistance of the "negative" resistor in the third balance, in ohms, and

f = the frequency, in cycles per second.

(*b*) *Two-Balance Method, C_2 Fixed.*—When there is not available a variable standard air capacitor capable of withstanding the test voltage, a fixed value standard air capacitor shall be employed for C_2. Two balances only will be required in this case. The first shall be made with C_x in circuit; R_1 shall be set at 10,000 ohms (100,000 ohms) or any convenient value; balance shall be secured by varying C_1 and R_4. Next C_2 shall be put into circuit, C_x being grounded and balance shall be secured by varying C_1 and R_1. Then, with only a small degree of approximation (see Appendix II):

$$C_p = C_2 \frac{C'_1}{C_1} \text{..............................} \text{Eq. (15)}$$

$$\tan \delta_p = \frac{10^{12}}{2\,\pi\, f} \left(\frac{1}{C'_1 R'_1} - \frac{1}{C''_1 R''_1} - \frac{K}{R'_4 C'_1} + \frac{K}{R'_4 C''_1} \right) \text{.....} \text{Eq. (16)}$$

where C_p = the equivalent parallel capacitance of the test capacitor formed from the test specimen, in micro-microfarads,

C_2 = the capacitance of the standard air capacitor, in micro-microfarads,

C'_1 = the capacitance of the "low voltage" capacitor in the first balance, in micro-microfarads,

C''_1 = the capacitance of the "low-voltage" capacitor in the second balance, in micro-microfarads,

R'_1 = the resistance of the "negative" resistor in the first balance, in ohms,

R''_1 = the resistance of the "negative" resistor in the second balance, in ohms,

R'_4 = the resistance of the "positive" resistor in the first balance, in ohms,

f = the frequency, in cycles per second, and

K = E'_4/E_4, the ratio of the "positive" voltage to the "negative" voltage. This ratio is usually near unity, although it may have other values especially when it is desirable to secure a more convenient value for R_4. When K is near unity its value may be secured from two successive comparisons of C_2 and C_1, before and after reversing the primary and secondary connections so that C_1 is supplied first from the "negative" voltage side of the transformer (as shown in Fig. 15) and then from the "positive" side (see Appendix II).

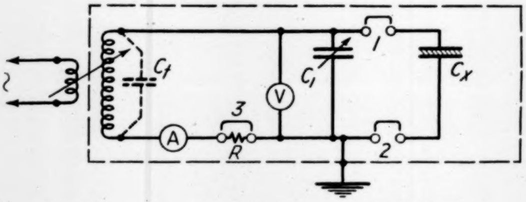

FIG. 15.—Tuned-Circuit Substitution Method.

Resonant Circuit Substitution Method

31. (*a*) See Fig. 15. This method is recommended for frequencies from about 100 kilocycles per second upward. The oscillator shall have a power rating sufficient to prevent any large reaction on frequency or voltage output when coupled to the measuring circuit. Several coupling coils will be needed when test measurements are to be made over a range of frequencies. The capacitor C_1 shall have a range up to say 200 micromicrofarads and shall be adjustable to 0.5 $\mu\mu F$. or better. It may be necessary, at some frequencies, to supplement C_1 with a second capacitor C_t, (shown in dotted line in Fig. 13) connected across the terminals of the coupling coil. The switches 1, 2 and 3 shall be formed with short links of copper wire dipping into mercury cups mounted on rods or tubes, 4 to 6 in. (10 to 15 cm.) in length, of quartz or high-resistivity glass. The resistors represented by R in Fig. 15 shall be short lengths of high-resistivity non-magnetic wire (advance or manganin is suitable) sealed into glass tubes for convenience in handling, arranged to bridge the mercury cups of switch 3. For most work a range of resistance from 0.5 ohm to 20 or 30 ohms will be adequate.

(*b*) The indicator of resonance and of the current strength may be either an ammeter A, or a vacuum tube voltmeter V. Both are shown in Fig. 15. The voltmeter has been found more satisfactory at frequencies of the order of 5 megacycles per second and upward. The ammeter A shall consist of a low-resistance heater, preferably of less than 2 ohms resistance, with a thermocouple which used in conjunction with a short-period low-resistance reflecting galvanometer shall give a full scale deflection for a current in the order of 10 to 20 milliamperes. The vacuum tube voltmeter shall have reasonably small inter-electrode capacitance and losses. The specimen shall be mounted on insulating pillars to reduce stray capacitance of adjacent objects and the "high" lead from switch 1 to the "high" electrode shall be as short as possible. The measurements shall be carried out inside a metal screen shielding enclosure and it is usually desirable to interpose an earthed screen between the coupling coil and the oscillator which serves as the source.

(*c*) For the first step, a suitable coupling coil shall be selected, switches 1, 2 and 3 shall be closed with the copper links, the source oscillator shall be brought to the desired frequency and the resonant circuit tuned by varying C_1 and also by introducing C_t if necessary. The coupling between the measuring circuit and the source shall then be altered to give a satisfactorily large deflection of the ammeter or voltmeter, whichever is being used. A careful adjustment of C_1 for perfect resonance shall then be made and the reading of the ammeter or voltmeter recorded. The links at switches 1 and 2 shall now be removed, the link at switch 3 shall be replaced with a resistor, say of 10 ohms. Resonance shall be again secured by varying C_1. A value of R shall then be inserted which will give a slightly larger deflection than when C_x was in circuit; this shall be followed by other values of R to give deflections as nearly equal as possible to that obtained with C_x, and other values of R to give somewhat smaller deflections. A slight readjustment of C_1 may be necessary and shall be recorded. The values of R and C_1 which will give the same deflection as with C_x in circuit shall then be obtained by interpolation.

$$C_p = \frac{C_1}{1 + \tan^2\delta_p} - C'_1 \text{ .... Eq. (17)}$$

$$\tan \delta_p = \frac{C_1}{C_1 - C'_1} \times 2\pi f C_1 R_1 \times 10^{-12} \text{ .... Eq. (18)}$$

C_p = the equivalent parallel capacitance of the test capacitor formed from the test specimen, in micro-microfarads,

C'_1 = the first resonant value of standard capacitor with C_x in circuit, in micro-microfarads,

C_1 = the second resonant value with C_x out of circuit, in micro-microfarads,

R_i = the interpolated value of series resistance to give same resonant current (or voltage) as with C_x in circuit, in ohms, and

f = the resonant frequency, in cycles per second.

REPORT

Report

32. The report shall include the following:

(*a*) A description of the material: that is, the name, grade, and color, and the name of the manufacturer,

(*b*) The following test conditions: the frequency in cycles (or kilocycles) per second; temperature of the atmosphere in degrees Centigrade; percentage relative humidity of the atmosphere; the conditioning of the specimen (hours at humidity and temperature); the kind of electrodes; and the voltage gradient in the dielectric while under test,

(*c*) The following values for the specimen: the capacitance of the specimen in micro-microfarads; effective area of the specimen electrodes; the average thickness of the specimen between electrodes,

(*d*) The power factor, the dielectric constant, and the loss factor of each specimen, and

(*e*) Method of measurement.

APPENDIX I

CORRECTIONS TO BE APPLIED TO TAN δ_p TO SECURE COS Θ_p

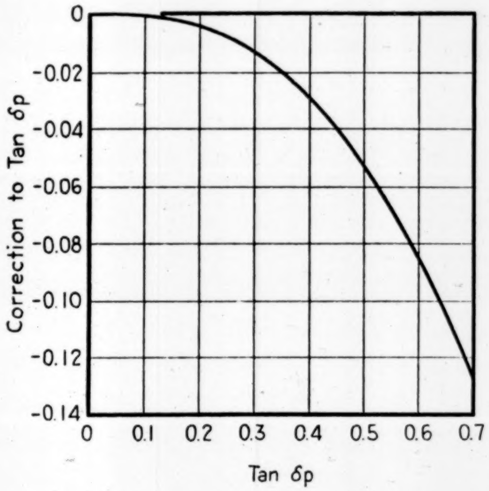

FIG. A1.—Corrections to be Applied to Tan δ_p to Secure Cos θ_p.

APPENDIX II

EXACT FORMULAS

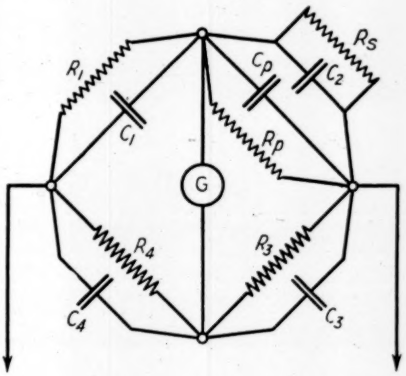

FIG. A2.—Generalized Diagram Showing Capacitors With Conductance and Resistors With Capacitance.

1. Conjugate Schering Bridge:

C_2R_s represents the standard air capacitor.

C_1R_1 represents the comparison air capacitor.

C_pR_p represents the test capacitor.

The capacitors C_3 and C_4 across the ratio arms R_3 and R_4 contain the stray capacitances of those resistors as well as the capacitances of the actual devices.

Two successive balances of the bridge shall be made, with and without the test capacitor C_x in place. From these the following are obtained:

$$C_p = \frac{C_2\,(1 + \tan\gamma_4 \tan\delta_2)}{(1 + \tan\gamma'_4 \tan[\delta_2 + \gamma'_4 - \gamma_4])} - C'_2 \ldots\ldots \text{Eq. (1)}$$

$$\tan\delta_p = \left(1 + \frac{C'_2}{C_p}\right)\tan[\delta_2 + \gamma'_4 - \gamma_4] - \frac{C'_2}{C_p}\tan\delta'_2 \ldots\ldots \text{Eq. (2)}$$

where $\tan\delta_2 = \frac{1}{\omega C_2 R_s}$ = power factor (approximate) of C_2 at second setting,

$\tan\delta'_2 = \frac{1}{\omega C'_2 R'_s}$ = power factor (approximate) of C_2 at first setting,

$\tan\gamma_4 = \omega C_4 R_4$, and

$\tan\gamma'_4 = \omega C'_4 R_4$.

II. High-Voltage Schering Bridge:

Standard capacitor C_2 not used; same as Conjugate Schering Bridge with direct comparison.

$$C_p = \frac{R_4}{R_3} C_1 \frac{(1 + \tan\gamma_3 \tan\delta_1)}{(1 + \tan\gamma_4 \tan[\gamma_4 + \delta_1 - \gamma_3])} \ldots\ldots \text{Eq. (3)}$$

$$\tan\delta_p = \tan(\gamma_4 + \delta_1 - \gamma_3) \ldots\ldots \text{Eq. (4)}$$

where $\tan\delta_1 = \frac{1}{\omega C_1 R_1}$ = power factor (approximate) of C_1,

$\tan\gamma_3 = \omega R_3 C_3$, and

$\tan\gamma_4 = \omega R_4 C_4$.

If the capacitances of R_3 and R_4 are negligible, C_3 and C_4 are the readings of the capacitors connected across them.

III. Parallel Resistance Bridge:

Diagram same as for Conjugate Schering Bridge except additional variable parallel resistance R_2 connected across C_pR_p. Two successive balances of the bridge shall be made, with and without the test capacitor C_x in place. From these the following are obtained:

$$C_p = C_2 - C'_2 \ldots\ldots \text{Eq. (5)}$$

$$\tan\delta_p = \tan\delta_m - \tan\delta'_m + \frac{C_2}{C_p}\tan\delta_2 - \frac{C'_2}{C_p}\tan\delta'_2 \ldots\ldots \text{Eq. (6)}$$

where $\tan\delta_2 = \frac{1}{\omega C_2 R_s}$ = power factor (approximate) of C_2 at second balance position,

$\tan\delta'_2 = \frac{1}{\omega C'_2 R'_3}$ = power factor (approximate) of C_2 at first balance position,

$\tan\delta_m = \frac{1}{\omega C_p R_2}$, and

$\tan\delta'_m = \frac{1}{\omega C_p R'_2}$.

If the change-of-standard method is not employed but dependence is placed on a single comparison with the standard air capacitor C_1, then:

$$C_p = \frac{R_4}{R_3} C_1 \frac{(1 + \tan\gamma_3 \tan\delta_1)}{(1 + \tan\gamma_4 \tan[\delta_1 + \gamma_4 - \gamma_3])} \quad \text{Eq. (7)}$$

$$\tan\delta_p = \tan(\delta_1 + \gamma_4 - \gamma_3) - \tan\delta_m \quad \text{Eq. (8)}$$

where the loss angles have the same significance as above.

IV. Series Resistance Bridge:

Diagram same as for Conjugate Schering Bridge, except C_1 and R_1 shall be connected in series instead of in parallel. Two successive balances of the bridge shall be made with and without the test capacitor C_x in place. From these the following are obtained:

$$C_p = C_2 \frac{(1 + \tan\beta_1 \tan\delta_2 + [\tan(\delta_2 + \gamma_3 - \beta_1)]\,[\tan\delta_2 - \tan\beta_1])}{(1 + \tan\beta'_1 \tan(\delta_2 + \beta'_1 - \beta_1) + [\tan(\delta_2 + \gamma_3 - \beta_1)]\,[\tan(\delta_2 + \beta'_1 - \beta_1) - \tan\beta'_1])} - C'_2 \quad \text{Eq. (9)}$$

$$\tan\delta_p = \left(1 + \frac{C'_2}{C_p}\right) \tan(\delta_2 + \beta'_1 - \beta_1) - \frac{C'_2}{C_p} \tan\delta'_2 \quad \text{Eq. (10)}$$

The various loss angles in Eq. (9) and Eq. (10) are defined by the following:

$\tan\beta_1 = \omega C_1 R_1$ $\qquad$ $\tan\gamma_3 = \omega C_3 R_3$

$\tan\beta'_1 = \omega C_1 R'_1$

$\tan\delta_2 = \dfrac{1}{\omega C_2 R_s}$ = power factor (approximate) of C_2 at second balance position, and

$\tan\delta'_2 = \dfrac{1}{\omega C'_2 R'_s}$ = power factor (approximate) of C_2 at first balance position.

If the change-of-standard method is not employed but dependence is placed on a single comparison with the standard air capacitor C_1R_1, then:

$$C_p = \frac{R_4}{R_3} C_1 \frac{1}{(1 + \tan\beta_1 \tan(\beta_1 + \gamma_4 - \gamma_3) + \tan\gamma_4 [\tan(\beta_1 + \gamma_4 - \gamma_3) - \tan\beta_1])} \quad \text{Eq. (11)}$$

$$\tan\delta_p = \tan(\beta_1 + \gamma_4 - \gamma_3) \quad \text{Eq. (12)}$$

where the loss angles have the same significance as above, with
$\tan\gamma_4 = \omega C_4 R_4$

V. Transformer Bridge:

(*a*) *Three-Balance Method, C_2 Variable.*—The exact formulas containing a term which takes into account the phase difference between the positive "voltage" E'_4, and the "negative" voltage E_4, are quite cumbersome.

$$C_p = C_2 (1 + A) \quad \text{Eq. (13)}$$

$$\tan\delta_p = \frac{1}{(1 + A)} \left(\tan\delta_2 + \frac{(\tan\delta'''_1 - \tan\delta'_1)(1 - P + \tan\delta_s \tan\delta_2)}{(1 - P)^2 + \tan^2\delta_s} \right) \quad \text{Eq. (14)}$$

where $\tan\delta_2 = \dfrac{1}{\omega C_2 R_2}$ = power factor (approximate) of the capacitor C_2,

$\tan\delta'''_1 = \dfrac{1}{\omega C_1 R'''_1}$ $\qquad$ $\tan\delta'_1 = \dfrac{1}{\omega C_1 R'_1}$

$\tan\delta_s = \dfrac{1}{\omega C_1} \left(\dfrac{1}{R_s} + \dfrac{1}{R'_1} - \dfrac{K}{R''_4} \right)$ $\qquad$ $K = \dfrac{E'_4}{E_4}$

$\frac{1}{\omega C_1 R_s}$ = power factor (approximate) of the capacitor, C_1

$$P = \frac{K \tan \delta_e}{\omega C_1 R''_4} \qquad \text{where } \delta_e = \text{phase difference between } E'_4 \text{ and } E_4$$

$$A = \frac{(\tan \delta'''_1 - \tan \delta'_1)\,(\tan \delta_s - [1 - P] \tan \delta_2)}{(1 - P)^2 + \tan^2 \delta_s}$$

It is obvious that the values of the resistors R_1 and R_4 must be kept high if the correction terms in these quantities are to have negligible values.

(*b*) *Two-Balance Method, C_2 Fixed.*—The complete expressions are quite lengthy and contain terms in $\left(1 - \frac{K \tan \delta_e}{C'_1 R'_4}\right)$ and $\left(1 - \frac{K \tan \delta_e}{C''_1 R'_4}\right)$ where δ_e is the phase difference between the voltages E_4 and E'_4. If δ_e is so small that these expressions differ from unity by negligible amounts, then:

$$C_p = C_2 \frac{C'_1}{C''_1} \; \frac{(1 - \tan \delta_2 \tan[\delta'_s - \delta''_s])(1 + \tan \delta'_s \tan \delta''_s)}{1 + \tan^2 \delta'_s} \text{............Eq. (15)}$$

$$\tan \delta_p = \tan (\delta'_s - \delta''_s + \delta_2) \text{....................................Eq. (16)}$$

The various angles are defined by the following:

$\tan \delta_2 = \frac{1}{\omega C_2 R_2}$ = power factor (approximate) of air capacitor C_2,

$$\tan \delta'_s = \frac{1}{\omega C'_1 R_1'} + \frac{1}{\omega C'_1 R'_s} - \frac{K}{\omega C'_1 R'_4}$$

$$\tan \delta''_s = \frac{1}{\omega C''_1 R''_1} + \frac{1}{\omega C''_1 R''_s} - \frac{K}{\omega C''_1 R'_4}$$

$\frac{1}{\omega C'_1 R'_s}$ = power factor (approximate) of capacitor C_1 at first balance, and

$\frac{1}{\omega C''_1 R''_s}$ = power factor (approximate) of capacitor C_1 at second balance.

As before R_1 and R_4 must be large in comparison to $\frac{1}{\omega C_1}$ in order that the correction terms be negligible in comparison to unity.

APPENDIX III

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HIGH-VOLTAGE SCHERING BRIDGE

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TENTATIVE METHOD OF TEST
FOR
SAPONIFICATION NUMBER OF ELECTRICAL INSULATING OILS[1]
(MODIFIED BAADER METHOD)

A.S.T.M. Designation: D 438 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1936.

Scope

1. This modified Baader saponification test is intended for the determination of the saponification number of electrical insulating oils.

Apparatus

2. The apparatus shall consist of the following:

(*a*) *Erlenmeyer Flask.*—An Erlenmeyer flask of 250-ml. capacity fitted with a ground-glass joint to a reliable reflux condenser or mushroom-type condenser. The Erlenmeyer flask should preferably be made of Jena G-20 glass.

(*b*) *Hot Plate.*—A suitable hot plate.

Solutions Required

3. The following solutions will be required:

(*a*) *Alcoholic Solution for Saponification.*—Dissolve about 6 g. of potassium hydroxide (purified by alcohol) in 500 ml. of 95 per cent purified ethyl alcohol. Allow the solution to settle in a dark place. Draw off the clear solution or filter through an asbestos filter and make up to 1 liter with 95 per cent alcohol. The solution so prepared shall then be allowed to stand at least 20 hr. before it is standardized.

(*b*) *Alcohol.*—Purify 95 per cent ethyl alcohol with silver oxide in the following manner: Dissolve 1.5 g. of silver nitrate c.p. in about 3 ml. of water and add to 1 liter of alcohol in a glass-stoppered bottle, and mix thoroughly. Dissolve 3 g. of potassium hydroxide (purified by alcohol), in 10 to 15 ml. of warm alcohol. After cooling, add slowly to the alcoholic silver nitrate solution, stirring slightly. Allow the precipitated silver oxide to settle, siphon off the clear solution and distill on a steam bath.

(*c*) *Standard Hydrochloric Acid Solution.*—0.1 *N* solution.

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee D-9 on Electrical Insulating Materials.

(*d*) *Alkali Blue Solution.*—Dissolve 0.6 g. of alkali blue *6-B* in 1500 ml. of 95 per cent alcohol and 1000 ml. of pure benzene.

Procedure

4. (*a*) *Blank Determination.*—Determinations shall be made in duplicate with the alcoholic potassium hydroxide solution in the following manner: Measure accurately into the flask (Note) 25 ml. of alcoholic potassium hydroxide solution from a standard burette, allowing 60 sec. total time for drawing and draining. Add 75 ml. of the alkali blue solution to the alcoholic potassium hydroxide in the flask, connect the flask to the reflux condenser and boil for 30 min. Titrate while hot with 0.1 *N* HCl.

NOTE.—The glassware must be chemically clean and it is recommended that flasks be cleaned with chromic acid solution, rinsed with distilled water and finally rinsed with alkali blue solution.

(*b*) *Test Procedure.*—Weigh 5 to 8 g. of the oil accurately to 0.01 g., by difference, from a small beaker into the saponification flask. Add 25 ml. of alcoholic potassium hydroxide solution and 75 ml. of the alkali blue solution in the same manner as for the blank, connect the flask to the reflux condenser and boil for 30 min. Titrate while hot with 0.1 *N* HCl.

(*c*) Titrations should be carried out as quickly and with as little splashing as possible, because the alkali blue solution is sensitive to carbon dioxide and air contamination. Any change after the first end point is ignored.

Calculation

5. Calculate the saponification number from the difference between the number of milliliters of 0.1 *N* HCl required for the determination and the average of the two blanks, using the following formula:

$$\text{Saponification number} = \frac{\text{Difference, milliliters} \times 5.611}{\text{Weight of oil in grams}}$$

Reproducibility of Results

6. With proper precautions observed, duplicate determinations by the same operator should agree within 0.1 saponification number. For different operators the tolerance may be double this amount.

TENTATIVE METHODS OF TESTING SHEET AND PLATE MATERIALS USED IN ELECTRICAL INSULATION[1]

A.S.T.M. Designation: D 229 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1925; Revised, 1926, 1928, 1930, 1931, 1932, 1934, 1935, 1936.

Scope. 1. These methods are intended to apply to stiff, flat sheet and plate materials, such as phenolic and other types of laminated sheets, vulcanized fiber, hard rubber, asbestos composition board, etc., to be used as electrical insulation.

Definition of Terms. 2. In referring to the cutting of the specimens and the application of the load, the following definitions apply:

Flatwise.—Load applied to the flat side of the original sheet or plate.

Edgewise.—Load applied to the edge of the original sheet or plate.

Lengthwise.—In the direction of the length of the sheet.

Crosswise.—In the direction at right angles to the length of the sheet.

Note.—When the sheet has the same length and width, one dimension shall arbitrarily be designated as the length, and the other as the width.

TENSILE STRENGTH

Apparatus. 3. Any standard type of testing machine may be used. The machine shall be accurate to within 1 per cent on the lowest load for which it is used. Jaws which tighten under load, such as wedge grip jaws, shall be used with the specimen properly aligned.

Specimens. 4. Tension test specimens shall conform to the dimensions shown in Fig. 1. The surfaces of the specimen shall be smooth and free from scratches.

Procedure. 5. Five specimens cut lengthwise and five specimens cut crosswise of the sheet shall be tested.

Temperature. 6. All tests shall be made at normal room temperature of about 20° C. (68° F.).

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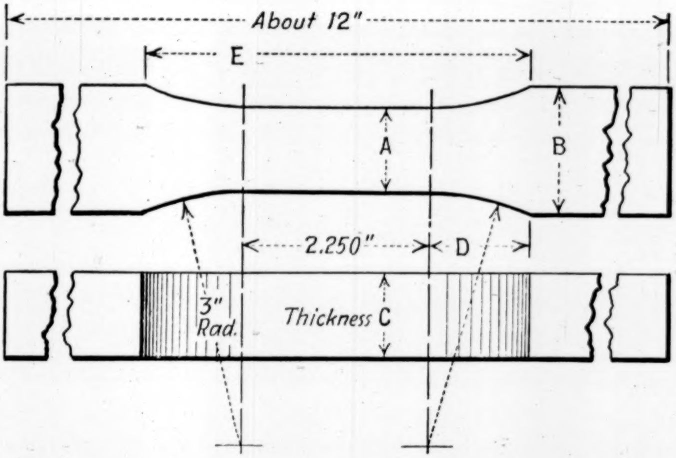
[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-9 on Electrical Insulating Materials.

Speed of Testing Machine. 7. The cross-head speed of the testing machine shall be such that the load can be accurately weighed, but shall not exceed 0.05 in. per minute when the machine is running idle.

Modulus of Elasticity. 8. When it is desired to determine the elongation under load, a suitable extensometer measuring the elongation on a 2-in. gage length shall be used. The cross-head speed of the testing machine shall not exceed 0.03 in. per minute when the machine is running idle.

Procedure. 9. The total change in length between zero load and a stress of 5000 lb. per sq. in. shall be determined.



When C is less than $\frac{1}{8}$ in., A is $\frac{1}{2}$ in., B is $\frac{3}{4}$ in., D is 0.857", E is 3.964 in.
When C is $\frac{1}{8}$ in. or over, A is 1 in., B is $1\frac{1}{2}$ in., D is 1.199", E is 4.648 in.

FIG. 1.—Tension Test Specimen for Laminated Sheet Insulating Materials.

Report. 10. The report shall include the following:

(*a*) The direction in which the specimen was taken, whether lengthwise or crosswise of the sheet.

(*b*) The thickness and width of each specimen in inches expressed to the nearest 0.001 in. or in centimeters expressed to the nearest 0.025 mm.

(*c*) The breaking load of each specimen, in pounds or kilograms.

(*d*) The tensile strength of each specimen, in pounds per square inch or in kilograms per square centimeter.

(*e*) The location and nature of the fracture.

(*f*) The elongation in inches at a stress of 5000 lb. per sq. in., if determined.

(*g*) The room temperature.

FLEXURAL STRENGTH

(FORMERLY CALLED TRANSVERSE STRENGTH)

(*A*) *For Materials $\frac{1}{32}$ in. or Over in Thickness*[1]

Apparatus. 11. (*a*) Any standard type of testing machine may be used. The machine shall have an accuracy of at least 1 per cent of the lowest load for which it is used.

(*b*) The specimen shall be tested as a simple beam loaded at the center. The supports shall have contact edges rounded to a radius of $\frac{1}{8}$ in. for material $\frac{1}{8}$ in. or over in thickness, and to a radius of $\frac{1}{16}$ in. for thinner materials. For material thinner than $\frac{1}{8}$ in. both supports shall be provided with a pin or other stop to align one side of the specimen perpendicular to the line of contact with the supports. The distance between the points of support shall be 4 in. for edgewise tests of all thicknesses and eight times the nominal thickness of the material to be tested for tests in the flatwise direction, except that the minimum span shall be $\frac{1}{2}$ in.

Specimen 12. The test specimen shall be $\frac{1}{2}$ in. in width except for specimens over $\frac{1}{2}$ in. in thickness tested in the flatwise direction, which shall have the width equal to the thickness of the specimen. The thickness shall be the full thickness of the sheet. The length shall be 1 in. greater than the distance between the points of support as specified in Section 11 (*b*).

Procedure 13. The specimens shall be tested as follows:

(*a*) Five specimens cut lengthwise of sheet, tested flatwise
(*b*) Five specimens cut lengthwise of sheet, tested edgewise.
(*c*) Five specimens cut crosswise of sheet, tested flatwise.
(*d*) Five specimens cut crosswise of sheet, tested edgewise.

Temperature of Tests. 14. All tests shall be made at normal room temperature of about 20° C. (68° F.).

Speed of Testing Machine. 15. The cross-head speed of the testing machine shall be such that the beam of the machine can be kept balanced, but shall not exceed 0.05 in. per minute when the machine is running idle.

Report. 16. The report shall include the following:

(*a*) The directions of cutting and loading of the specimen as specified in Section 13.

(*b*) The thickness and width of each specimen in inches expressed to the nearest 0.001 in. or in centimeters expressed to the nearest 0.025 mm.

(*c*) The breaking load of each specimen in pounds or kilograms.

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[1] Conventional flexure tests in a flatwise direction are not recommended for materials thinner than $\frac{1}{32}$ in. nor in the edgewise direction for materials thinner than $\frac{1}{2}$ in.

(*d*) The maximum fiber stress in pounds per square inch or kilograms per square centimeter calculated from the formula:

$$S = \frac{3}{2}\frac{Pl}{bd^2}$$

where S = maximum fiber stress;

P = breaking load in pounds or kilograms;

l = distance between supports in inches or centimeters;

b = width of specimen in inches or centimeters;

d = depth of specimen in inches or centimeters.

(*e*) The room temperature.

COMPRESSIVE STRENGTH

Apparatus.

17. Any standard testing machine may be used provided it is accurate within 1 per cent of the lowest load for which it is used. One end of the specimen shall bear upon an accurately centered spherical bearing block, located whenever practicable, at the top, and the metal bearing plates shall be directly in contact with the ends of the test specimen.

Specimen.

18. (*a*) For sheets 1 in. in thickness or over, the test specimen shall be a 1-in. cube, the faces of which shall be flat and perpendicular to the axes, being ground to this condition if necessary.

(*b*) For sheets less than 1 in. in thickness, the specimen shall consist of a pile of sheets 1 in. square with a minimum number of layers to produce a height of at least 1 in.

Procedure.

19. (*a*) For sheets 1 in. in thickness or over, three specimens shall be crushed in the condition in which they are received with the load applied flatwise, three specimens with the load applied edgewise-lengthwise of the sheet and three specimens with the load applied edgewise-crosswise of the sheet.

(*b*) For sheets less than 1 in. in thickness, three specimens shall be crushed in the condition in which they are received with the load applied flatwise of the sheet.

20. The load shall be applied on the ends of the specimen and the crosshead speed of the testing machine shall be such that the load can be accurately weighed but shall not exceed 0.050 in. (1.27 mm.) per minute when the machine is running idle. For the best results use the slowest possible speed.

Report.

21. The report shall include the following:

(*a*) The dimensions of each specimen in inches expressed to the nearest 0.001 in. or in centimeters expressed to the nearest 0.025 mm.

(*b*) The direction of application of the load;

(*c*) The load on each specimen in pounds or kilograms at the first sign of failure;

(*d*) The ultimate compressive strength in pounds per square inch or kilograms per square millimeter, of each specimen, calculated from the area of each specimen measured before the load is applied;

(*e*) The general character of the material tested; with a description of how it acts under the applied load.

Resistance to Impact. 22. (*a*) Resistance to impact shall be determined in accordance with the Tentative Methods of Testing Electrical Insulating Materials for Resistance to Impact (A.S.T.M. Designation: D 256 - 34 T) of the American Society for Testing Materials.[1]

Specimen. (*b*) Specimens for the Charpy test may be notched or unnotched, as desired, according to conditions of service, and for the Izod test shall be notched. Specimens shall be cut both lengthwise and crosswise of the sheet.

NOTE.—The unnotched specimen gives a higher strength than the notched specimen and the ratio of the strength of the unnotched specimen to that of the notched specimen varies with different materials.

WATER ABSORPTION TESTS

Scope. 23. The water absorption tests are intended to determine the rate at which water is absorbed by the material when immersed, the total quantity absorbed at saturation, and the volatile content as received.

NOTE.—The electrical properties of different materials are not necessarily affected to the same extent by the same increase in moisture content so that the water absorption test must be correlated with the desired electrical tests.

The water immersion test and exposure to air of high humidity are not always directly comparable and should be considered before substituting one for the other.

(*A*) *Rate of Absorption*

Specimen. 24. The test specimen shall be 3 by 1 in. by the thickness of the material. It shall be sawed or sheared from the sample so as to have smooth edges free from cracks. The cut edges of all test specimens shall be finished with No. 0 or finer sandpaper or emery cloth. Sawing and sandpapering operations should be slow enough so that the material is not heated appreciably. The thickness in inches to the nearest 0.001 in. shall be measured on the original specimen at the center.

Procedure. 25. To determine the rate of absorption, two specimens shall be tested individually as follows:

(*a*) The specimen shall be weighed, dried in an oven for 1 hour at from 105 to 110° C., cooled in a desiccator and immediately re-weighed. The difference between the original weight and the dry weight shall be recorded as loss in weight on drying. The percentage loss in weight shall be calculated on the original weight.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, p. 995 (1934); also 1936 Book of A.S.T.M. Tentative Standards, p. 905.

(*b*) The dried specimen shall then be immersed in distilled water maintained at a temperature of 25° C. ± 2° C. (77° F. ± 3.6° F.) throughout the test. At the end of 2 hours the specimen shall be removed from the water, the surface water wiped off with a dry cloth and the specimen weighed immediately and then replaced in the water. If the specimen is $\frac{1}{16}$ in. in thickness or less it shall be weighed in a weighing bottle. The difference between the weight of the wet specimen and that of the dry specimen shall be recorded as the weight of water absorbed in 2 hours. The percentage of water absorbed shall be calculated on the weight of the dry specimen.

(*c*) After 24 hours immersion the specimen shall again be removed from the water, the surface water wiped off with a dry cloth and the specimen weighed. The difference between the weight of the specimen after 24 hours immersion and the weight of the dry specimen shall be recorded as the water absorbed in 24 hours. The percentage of water absorbed shall be calculated on the weight of the dry specimen. If the individual 24-hour absorptions differ by more than 10 per cent from the average absorption of the two specimens the test shall be repeated.

Report. 26. The report shall include the values for each of the two specimens and the average values as follows:

(*a*) The thickness of the specimen before the test, to the nearest 0.001 in.;

(*b*) The percentage loss in weight on drying calculated on the original weight;

(*c*) The percentage of water absorbed in 2 hours and in 24 hours calculated on the dry weight

(*B*) *Total Absorption at Saturation*

Specimen. 27. (*a*) The test specimen shall be 3 by 1 in. by the thickness of the material. It shall be sawed or sheared from the sample so as to have smooth edges free from cracks. The cut edges of all test specimens shall be finished with No. 0 or finer sandpaper or emery cloth. Sawing and sandpapering operations should be slow enough so that the material is not heated appreciably. The thickness in inches measured to the nearest 0.001 in. shall be measured on the original specimen at the center and on the reduced specimen in case a reduced specimen is used (see Paragraph (*b*)).

(*b*) When the sample for determining total absorption is so thick that too long a time is required for saturation using the full thickness, the thickness may be reduced as follows: The sample shall be machined to a thickness of about $\frac{5}{64}$ in., both surfaces parallel to the laminations being machined off. This may readily be done with a smooth-cut circular saw. It shall then be sanded to $\frac{1}{16}$ in. in thickness, finishing with No. 0 or finer sandpaper. While the sanded surfaces of the sample should be approximately parallel with the laminations, the thickness may vary ±0.010 in., since the object is to provide comparable specimens which will reach saturation in a reasonable time. The machined and sanded sample shall then be cut into specimens 3 by 1 in. and the edges sanded.

Procedure. 28. To determine the total water absorption at saturation, two specimens shall be tested individually as follows:

(*a*) The specimen shall be weighed, dried in an oven for 1 hour at from 105 to 110° C., cooled in a desiccator and immediately reweighed. The difference between the original weight and the dry weight shall be recorded as loss of weight on drying. The percentage loss in weight shall be calculated on the original weight.

(*b*) The dried specimen shall then be immersed in distilled water at a temperature of from 20 to 30° C. At the end of 24 hours the specimen shall be removed from the water, the surface water wiped off with a dry cloth and the specimen weighed immediately and then replaced in the water. The weighings shall be repeated every day for the first week and every week thereafter until the increase in weight, as shown by three consecutive weighings, averages less than 1 per cent of the total increase in weight, when the specimen shall be considered to be saturated.

(*c*) The difference between the saturated weight and that of the dry weight shall be considered as the water absorbed at saturation. The percentage of water absorbed shall be calculated on the dry weight of the specimen.

Report. 29. This report shall include the values for each of the two specimens as follows:

(*a*) The original thickness of material, measured to the nearest 0.001 in.;

(*b*) If a reduced specimen is used, the thickness measured to the nearest 0.001 in.;

(*c*) The percentage loss in weight on drying, calculated on the original weight;

(*d*) The percentage of water absorbed at saturation, calculated on the dry weight.

(*C*) *Volatile Matter*

Specimen. 30. The test specimen shall conform to the requirements specified in Section 12.

Procedure. 31. To determine the volatile matter, two specimens shall be tested individually as follows:

The specimen shall be weighed, dried in an oven at from 105 to 110° C. until the decrease in weight as shown by two consecutive weighings at least 24 hours apart is less than 1 per cent of the total decrease in weight. The difference between the original weight and the dry weight shall be recorded as the volatile matter present in the specimen as received (this includes in addition to water any volatile solvent left during manufacture). The percentage of volatile matter shall be based on the weight of the dry specimen.

Report. 32. The report shall include the values for each of the two specimens as follows:

(*a*) The original thickness of the material measured to the nearest 0.001 in.;

(*b*) The percentage of volatile matter, based on the weight of the dry specimen.

DIELECTRIC STRENGTH

Dielectric Strength. 33. The dielectric strength shall be determined in accordance with the Tentative Methods of Testing Sheet, Tape, and Molded Insulating Materials for Dielectric Strength (A.S.T.M. Designation: D 149 - 36 T) of the American Society for Testing Materials.[1]

PHASE DIFFERENCE (POWER FACTOR) AND DIELECTRIC CONSTANT

Dielectric Constant. 34. The phase difference and dielectric constant shall be determined in accordance with the Tentative Methods of Testing Electrical Insulating Materials for Power Factor and Dielectric Constant (A.S.T.M. Designation: D 150 - 36 T) of the American Society for Testing Materials.[2]

BONDING STRENGTH

For Laminated Materials $\frac{3}{16}$ in. or Over in Thickness

Apparatus. 35. Any standard type of testing machine may be used, providing it is accurate within 1 per cent of the lowest load for which it is used. To this shall be fitted a head containing a 10-mm. steel ball.

Specimens. 36. Test specimens shall be 1 in. square, smoothly and accurately cut on a smooth saw.

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[1] See p. 918.

[2] See p. 955.

Procedure. 37. Five specimens shall be tested. These shall be placed on edge and the steel ball shall center accurately between the edges and ends of the specimen.

Temperature. 38. All tests shall be made at normal room temperature of about 20° C. (68° F.).

Speed of Testing Machine. 39. The speed of the cross-head of the testing machine shall be such that the load can be accurately weighed, but shall not exceed 0.05 in. per minute when the machine is running idle.

Report. 40. The report shall include the following:

(*a*) the thickness of the material; and

(*b*) the load, expressed in pounds or kilograms, required to split the specimen.

ROCKWELL HARDNESS

Apparatus. 41. (*a*) The Rockwell hardness tester shall be used, conforming to the requirements of the Standard Methods of Rockwell Hardness Testing of Metallic Materials (A.S.T.M. Designation: E 18) of the American Society for Testing Materials.[1]

(*b*) The hardness shall be determined using a $\frac{1}{4}$-in. ball penetrator, a minor load of 10 kg. and a major load of 100 kg. The readings shall be taken on the red scale and shall be recorded as follows: Count the number of times the needle passes through zero on the red scale on the application of the major load. Subtract from this the number of times the needle passes through zero upon the removal of this load. If the difference is zero, the reading shall be recorded as over 100. If the difference is 1, the reading shall be recorded as between 0 and 100 and, if the difference is 2, the reading shall be recorded as negative.

Specimen. 42. (*a*) The specimen shall have a minimum thickness of $\frac{1}{4}$ in. The specimen may be composed of a pile-up of several pieces of the material of the same thickness, providing that precaution is taken that the surfaces of the pieces are in contact and not held apart by burrs from saw cuts, etc. The area of the specimen shall be 1 in. square if cut from sheet stock or other shape of at least this area.

(*b*) Care shall be taken that the test is not made so near the edge of the specimen that it will break out when the major load is applied.

(*c*) The specimen shall be supported in such a manner as to prevent errors due to overhang, when it does not balance itself on the anvil.

(*d*) All tests shall be made at normal room temperature of about 20° C. (68° F.).

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[1] 1936 Book of A.S.T.M. Standards, Part I, p. 824.

NOTE.—It should be noted that some materials such as laminated phenolic plates show an appreciable variation in the Rockwell hardness with variation in temperature as small as 8° C. (15° F.).

Procedure

43. The procedure outlined in the Standard Methods E 18[1] shall be followed. The adjustment of speed of load application and the time of application of the major load are of great importance. The machine shall be so adjusted that the major load will be fully applied in from 6 to 8 seconds as a longer time will give an erroneous result due to "creeping" of some materials.

Report.

44. The report shall include the following:

(*a*) The Rockwell hardness number read on the red scale, the major load and the diameter of the penetrator. The letter M shall precede the hardness number;

(*b*) The total thickness of the specimen;

(*c*) The number of pieces in a specimen and their average thickness, and

(*d*) The room temperature.

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[1] 1936 Book of A.S.T.M. Standards, Part I, p. 824.

TENTATIVE METHODS OF TESTING SOLID FILLING AND TREATING COMPOUNDS USED FOR ELECTRICAL INSULATION[1]

A.S.T.M. Designation: D 176 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1923; REVISED, 1924, 1925, 1929, 1933, 1934, 1935, 1936.

Scope

1. These methods cover physical and electrical tests for solid filling and treating compounds for electrical insulation.

NOTE.—Before testing under these methods it may be necessary to degasify (*a*) materials which tend to entrap gases (usually due to high viscosity) and/or (*b*) materials which tend to froth on heating. (See Appendix I.).

PHYSICAL TESTS

General Physical Tests

2. Each of the following tests shall be made in accordance with the method of test applicable, of the American Society for Testing Materials, as indicated:

(*a*) *Melting Point:* Standard Method of Test for Melting Point of Petrolatum (A.S.T.M. Designation: D 127).[2]

(*b*) *Softening Point,* for compounds having no definite melting point: Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (A.S.T.M. Designation: D 36),[3] or Standard Method of Test for Softening Point of Tar Products (Cube-in-Water Method) (A.S.T.M. Designation: D 61).[4] The method used should be indicated in the report.

(*c*) *Flash and Fire Points:* Standard Method of Test for Flash and Fire Points by Means of Open Cup (A.S.T.M. Designation: D 92).[5]

(*d*) *Evaporation:* Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (A.S.T.M. Designation: D 6).[6]

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-9 on Electrical Insulating Materials.

[2] 1936 Book of A.S.T.M. Standards, Part II, p. 942.

[3] *Ibid.*, p. 1098.

[4] *Ibid.*, p. 1103.

[5] *Ibid.*, p. 892.

[6] *Ibid.*, p. 1071.

(*e*) *Viscosity,* Temperature range from melting point to 150 C.: Saybolt Furol, Standard Method of Test for Viscosity by Means of the Saybolt Viscosimeter (A.S.T.M. Designation: D 88).[1]

(*f*) *Penetration Test,* Temperature range from melting or softening point to −25 C.: Standard Method of Test for Penetration of Bituminous Materials (A.S.T.M. Designation: D 5).[2]

Brittleness

3. To determine the brittleness of the material, the compound shall be spread on a piece of sheet metal in a layer $\frac{1}{16}$ in. in thickness. It shall then be submerged in water having a temperature at least 20 F. above the expected breaking point. It shall then be cooled 5 F. and held at this temperature for 5 minutes. The cooling shall then be continued in increments of 5 F. At each temperature interval the compounds shall be tested with the blade of a knife, inserting the point with the blade as nearly parallel with the sheet metal as is practicable, and pulling the compound from the sheet metal as rapidly as possible by rotating the blade about its back as an axis. The temperature at which the compound no longer stretches but snaps, shall be considered the breaking point.

SPECIFIC GRAVITY

Scope

4. This test is intended to determine the specific gravity of both untreated and degasified compounds at any temperature. The approximate volume occupied by entrapped gas at any temperature can be calculated from the difference in specific gravity of an untreated and a degasified sample at that same temperature.

Procedure

5. (*a*) The specific gravity shall be determined by the Standard Method of Test for Specific Gravity of Asphalts and Tar Pitches Sufficiently Solid to be Handled in Fragments (A.S.T.M. Designation: D 71)[3] or by the Standard Method of Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements and Soft Tar Pitches (A.S.T.M. Designation: D 70)[4] of the American Society for Testing Materials.

(*b*) If degasification is required, it shall be performed as described in Section 11 and Appendix I.

Volume of Entrapped Gases

6. The percentage of entrapped gases may be calculated from the following formula:

$$\text{Volume, in per cent, of entrapped gases} = \frac{\text{sp. gr. of degasified compound} - \text{sp. gr. of untreated compound}}{\text{sp. gr. of degasified compound}} \times 100$$

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 982.
[2] *Ibid.*, p. 1080.
[3] *Ibid.*, p. 1108.
[4] *Ibid.*, p. 1110.

COEFFICIENT OF EXPANSION

NOTE.—Certain materials when cooled form voids within the mass and no satisfactory method has been found to measure their coefficient of expansion.

Scope

7. These methods are intended for determining the true and effective coefficient of expansion of compounds. The true coefficient of expansion is for compounds which are free of entrapped gases. The effective coefficient of expansion is the coefficient for material which has not been degasified just prior to test. It is important for many purposes to know the effective coefficient of the material as received or after heating to the maximum temperature of application. Consistent results, however, may only be obtained with gas-free compounds.

Methods

8. The following methods are covered:

Methods A and B.—Methods *A* and *B* for true coefficient of expansion are intended for use only where the uniformity of the material under test justifies a high degree of precision. Method *A* is suitable for testing low-viscosity types such as waxes and petrolatums. Method *B* is suitable for testing asphalts and high-viscosity materials, also for opaque materials which may give difficulty in reading the glass scale of Method *A*.

Methods C, D and E.—Methods *C*, *D* and *E* are intended for faster testing where high precision may not be justified. These methods may be used for determining either true or effective coefficient of expansion.

Method A. Using Glass Flask

Apparatus

9. (*a*) *Flask.*—The flask[1] shall hold approximately 250 ml. to the zero mark, and the neck of the flask shall be 1 cm. in internal diameter and graduated for 25 ml. in 0.1-ml. divisions.

(*b*) *Oil Bath.*—The cylindrical oil bath for heating the sample shall be approximately 10 in. (25.4 cm.) in inside diameter and 20 in. (50.8 cm.) in inside depth with a false bottom 1 in. from the bottom and shall have provision for circulating and heating the oil.

(*c*) *Lead Collar.*—A lead collar shall be hung on the flask during test to prevent the oil currents of the bath from moving the flask.

Calibration

10. The capacity of the flask at the zero point and several points on the scale shall be determined by filling the flask with distilled water at a known temperature and weighing.

Procedure

11. (*a*) The flask shall be maintained under a vacuum of 25 in. of mercury and a temperature 50 C. higher than the softening point

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[1] A Pyrex or quartz glass flask is very satisfactory for this purpose.

(ring-and-ball method, as determined under Section 2 (*b*)) while being filled and for approximately 30 min. after filling is complete. The flask shall be filled to within the last milliliter marked on the neck when held at the maximum test temperature and slowly cooled to room temperature (10 to 12 hr.). Before starting the test, the flask shall be examined for the presence of cavities or irregular contraction of the compound. Some compounds after cooling below the liquid state, tend to stick to the sides of the neck of the flask. In such cases it is necessary to gradually warm the neck and flow the compound to meet the rest, after which the flask shall be placed in the bath for several hours to insure temperature equilibrium.

(*b*) With the compound satisfactorily placed in the flask at the lowest temperature, the height of the column in the neck shall be read and the bath then slowly heated. Readings shall be taken at 50 C. intervals, holding the bath as constant as possible at each point until no more expansion occurs at that point, the procedure being repeated for each point until maximum temperature is reached.

(*c*) *Precautions.*—During the test, temperature readings shall be taken at top and bottom of the bath to detect any variation. Readings of the expansion of the compound shall be made at intervals long enough to insure uniform temperature distribution and complete movement of the compound. Until complete liquefaction, the interval should be 3 to 4 hr.; after liquefaction it may be reduced to 30 min.

Calculation

12. (*a*) After securing the readings over the temperature range desired, a curve shall be plotted from the temperature and expansion readings from which the coefficient of expansion shall be calculated from the following formula:

$$\text{Coefficient of expansion of the compound} = \frac{V_1 - V}{(T_1 - T)\,V} + C$$

where V = the original volume occupied by the compound;

V_1 = the volume at higher temperature occupied by the compound;

T = the original temperature;

T_1 = the higher temperature, and

C = a constant = coefficient of expansion of glass container.

(*b*) The coefficient of expansion shall be calculated for three temperature ranges, as follows:

(*1*) From the minimum temperature at which the measurement was made to 10 C. below the melting point. This is intended to give the average coefficient for the solid condition.

(*2*) From 5 C. above the melting point to 100 C. This is intended to give the average coefficient for the liquid condition.

(*3*) From the minimum temperature at which a measurement was made to 100 C.

Method B. Using Metallic Cell

Apparatus

13. (*a*) *Metal Cell.*—The cell shall be made of steel, consisting of four parts, a cylinder about 2.5 in. in internal diameter, having a rigid bottom, a metallic gasket, a cover to which a steel capillary tube is attached and an auxiliary cover for introducing the compound to be tested while the cell is under a vacuum. The cell shall have an internal volume of approximately 250 ml. A metallic cell that has been found suitable is described in Appendix II.

(*b*) *Oil Bath.*—The oil bath shall be the same as described in Section 9 (*b*), Method *A*, with the exception that provision shall be made for supporting the metal cell.

Calibration

14. The cell shall be calibrated to determine its volume at various temperatures as follows:

(*a*) Weigh the assembled cell to determine its tare weight.

(*b*) Fill the cell with mercury until replacing the cover causes some to extrude through the capillary tubing. Record the weight of the cell and mercury and note the temperature.

(*c*) Place cell in the oil bath in an inverted position. The capillary tubing should extend over the side of the oil bath in such a way that the extruded mercury may be caught in a beaker. The oil bath which is several degrees above room temperature causes some mercury to be extruded from the capillary tube. When all expansion has taken place, weigh the mercury collected.

(*d*) Adjust the oil bath for other test temperatures and note the amounts of mercury extruded. The weight of mercury in the cell at any temperature is thus determined and the volume may be calculated.

Procedure

15. (*a*) The cell shall be fitted with the auxiliary cover and held in an upright position in the oil bath while filling. A vacuum of 25 in. of mercury and a temperature 50 C. higher than the softening point (ring-and-ball method, as determined under Section 2 (*b*)) shall be maintained while filling and for at least 30 min. after the cell has been filled to within approximately $\frac{1}{4}$ in. of the cover. The cell shall then be slowly cooled to room temperature, and any irregularities in the surface of the compound removed.

(*b*) The auxiliary cover shall be replaced with the standard cover and the cell and compound weighed.

(*c*) Sufficient mercury shall be poured into the cell so that some is extruded when the cover is screwed down. The cell shall then be weighed again.

(*d*) The cell shall then be inverted and placed in the oil bath, and the procedure outlined under calibration, Section 14 (*c*) and (*d*) again followed for 5 C. intervals.

(*e*) *Precautions.*—Only clean, distilled mercury shall be used. During the test, temperature readings shall be taken at top and bottom of the bath to detect any variation. Readings of the expansion of the compound should be made at intervals long enough to insure uniform temperature distribution and complete movement of the compound. Until complete liquefaction, the interval should be 3 to 4 hr.; after liquefaction, it may be reduced to 30 min.

Calculation

16. (*a*) After volumetric determinations have been made over the desired temperature range, a curve shall be plotted between volume and temperature readings from which the coefficient of expansion shall be calculated from the following formula:

$$\text{Coefficient of expansion of the compound} = \frac{V_1 - V}{(T_1 - T)\,V}$$

where V = the original volume occupied by the compound;

V_1 = the volume at higher temperature occupied by the compound;

T = the original temperature, and

T_1 = the final temperature.

(*b*) The coefficient of expansion shall be calculated for the same three ranges as prescribed in Method *A*, Section 12 (*b*).

Report

17. The report shall include the following:

(*a*) The type of cell used.

(*b*) A copy of the volume-temperature curve.

(*c*) The temperature ranges as defined under Section 12 (*b*) or 16 (*b*).

(*d*) The coefficient of expansion corresponding to each of the three temperature ranges.

Method C. Specific Gravity Method

Procedure

18. The specific gravity of untreated or degasified compound at two test temperatures may be found by either of the procedures specified in Section 5.

Calculation

19. From the temperature and specific gravity readings the coefficient of expansion shall be calculated from the following formula:

$$\text{Coefficient of expansion} = \frac{\text{sp. gr. at } T - \text{sp. gr. at } T_1}{(T_1 - T)\text{ sp. gr. at } T_1}$$

where T = the initial temperature, and
T_1 = the higher temperature.

Method D. Pycnometer Contraction

Scope

20. This method is a modification of the specific gravity method (Method *C*). It may be applied to either untreated or degasified compounds.

Apparatus

21. (*a*) *Flask.*—A 100-ml. volumetric glass[1] flask shall be used and the zero mark shall be as near as possible to the bulb of the flask.

(*b*) *Oil Bath.*—The oil bath may consist of a tall-form glass[1] beaker of sufficient size so that when the flask is supported about 1 in. from the bottom the oil level will reach at least to the zero mark of the flask.

(*c*) *Metal Collar.*—Lead or iron collars placed on the neck of the flask shall be used during heating to prevent oil currents of the bath from moving the flask.

Procedure

22. (*a*) The flask shall be weighed and then filled to within approximately 10 ml. of the zero mark with the compound to be tested, care being taken that at no time shall the temperature of the compound exceed the softening point (ring-and-ball method) by more than 10 C. Care shall also be taken so that none of the compound remains in the stem of the flask. The flask shall be cooled to room temperature, weighed, immersed in the oil bath and placed in an oven previously heated to the maximum temperature at which the test is to be run. After the oil bath reaches the test temperature it shall be allowed to remain at this temperature for 1 hr. The flask shall be removed from the oven, and mercury from a burette shall be quickly poured into it until the level of the compound is within 0.5 ml. of the zero mark. The quantity of mercury used shall be noted in milliliters. The flask shall be replaced in the oven for 20 min., removed again and the mercury titration shall be continued until the level of the compound is exactly at the zero mark. The number of milliliters of mercury used in both titrations shall be recorded.

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[1] Pyrex glass or other material with equally low coefficient of expansion is very satisfactory for this purpose.

(*b*) The oven temperature shall be reset at the next lower test point, temperature equilibrium allowed for as above, and the titration shall be repeated. The same procedure shall be continued at all subsequent test points, the milliliters of mercury added at each point being recorded.

Calculations

23. To find the coefficient of expansion of the material between any two temperatures, the calculations shall be made as follows:

$$\text{Volume of mercury } A \text{ at room temperature corrected to temperature } t = A + 0.000182A\,(t - 20)$$

Example.—If volume of flask is 100 ml. at 20 C.; volume at $t = 100 + 0.0025\,(t - 20)$ ml.

$$\text{Let } X = V_1 - M_1 = \text{the volume of compound at } T_1,$$
$$\text{Let } Y = V_2 - M_2 = \text{the volume of compound at } T_2,$$

$$\text{Then the expansion in cu. cm. per gram, } T_1 - T_2 = \frac{X}{W} - \frac{Y}{W}$$

$$\text{the expansion per cu. cm., } T_1 - T_2 = \frac{\dfrac{X-Y}{W}}{\dfrac{Y}{W}} = \frac{X-Y}{Y}$$

$$\text{the coefficient of expansion, cu. cm. per cu. cm. per degree Centigrade} = \frac{X-Y}{Y\,(T_1 - T_2)}$$

where W = the weight of sample in grams

T_1 = the higher temperature in degrees Centigrade

T_2 = the lower temperature in degrees Centigrade

M_1 = milliliters of mercury (corrected) added at T_1

M_2 = the sum of milliliters of mercury (corrected) added at T_1 and at T_2

V_1 = the corrected volume of flask at T_1

V_2 = the corrected volume of flask at T_2

To obtain the curve of expansion, plot the points $\frac{W}{X}$, $\frac{W}{Y}$, etc., which are the densities at various temperatures.

Method E. Pycnometer Expansion

Scope

24. This method is another modification of the specific gravity method (Method *C*) and may also be applied to either untreated or degasified materials.

Apparatus and Calibration

25. The pycnometer and bath required are the same as described in Section 21, except that the neck of the flask shall be cut off at the 100-ml.

point and ground square. A metal pycnometer may be used provided its coefficient of expansion is known and is used in Section 27.

Procedure

26. In this procedure the pycnometer shall be allowed to cool slowly to the lowest test temperature. During the cooling period the flask shall be kept filled by adding more compound and after equilibrium is reached the excess material shall be removed by passing a sharp, flat blade over the rim. The flask shall then be removed from the bath and quickly weighed. Knowing the tare weight and volume of the flask, the specific gravity may be determined. For successively higher temperatures, it is only necessary to weigh the extruded portion.

Calculations

27. From the temperature and weight readings the coefficient of expansion may be calculated from the following formula:

$$\text{Coefficient of expansion} = \frac{W - W_1}{W_1 (T_1 - \mathrm{T})} - \frac{WC}{W_1}$$

where W = the initial weight of the compound in the flask
W_1 = the weight of the compound in the flask at higher temperature
T = the initial temperature
T_1 = the higher temperature
C = the coefficient of expansion of the flask

Method F. Plummet Displacement

Scope

28. This method is another modification of the specific gravity method (Method C).

Apparatus

29. The apparatus shall consist of the following:

(*a*) *Balance.*—An analytical balance equipped with pan straddle.

(*b*) *Plummet.*—An aluminum plummet of suitable shape weighing 5 to 10 g.

(*c*) *Beaker.*—A 400-ml. glass[1] beaker wrapped with asbestos.

(*d*) *Thermometer.*—A thermometer of suitable range.

(*e*) *Wire.*—Two pieces of fine copper wire.

Procedure

30. The specific gravity at pouring temperature shall be calculated from the weight of compound displaced by the calibrated aluminum plummet.

31. (*a*) *Calibration of Plummet.*—The following weight determinations of the plummet, to the nearest 1 mg., shall be made:

a = the weight in air;
b = the weight suspended in water at 25 C. (77 F.).

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[1] Pyrex glass or other material with equally low coefficient of expansion is very satisfactory for this purpose.

Then: $a - b$ = the weight of water displacement at 25 C. (77 F.).

The value of the plummet displacement (D_{t_p}) in terms of grams of water at 25 C. (77 F.) shall then be corrected to the pouring temperature, t_p, in Centigrade degrees by means of the following formula:

$$D_{t_p} = 0.000076^{a}\,(t_p - 25)\,(a - b) + (a - b)$$

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[a] Coefficient of cubical expansion of aluminum per deg. Cent.

(*b*) *Testing of the Sample.*—The sample shall be carefully melted in the beaker and the temperature raised to approximately 15 C. (27 F.) above the desired test temperature. The beaker shall be placed on the straddle and the plummet suspended in the compound by the fine copper wire. (The weight of the wire should be balanced by placing an equal weight of the wire on the opposite balance pan.)

The scales shall be balanced approximately and at the same time the sample shall be stirred slowly, using the thermometer as a stirring rod. When the sample has cooled to the desired temperature, the weighing shall be completed rapidly.

(*c*) *Calculation of Specific Gravity, t_p/25 C.*—The specific gravity shall be calculated from following formula:

$$\text{Sp. Gr., } t_p/25\text{ C.} = \frac{\text{Weight of Plummet in Air} - \text{Weight of Plummet in Compound}}{D_{t_p}}.$$

Calculation of Coefficient of Expansion

32. After the specific gravity of the sample at 25 C. (77 F.), and at pouring temperatures have been determined according to the above described methods, the coefficient of expansion shall be calculated according to the formula given in Section 19.

ELECTRICAL TESTS

DIELECTRIC STRENGTH TEST

Dielectric Strength

33. (*a*) This test is intended to determine the dielectric strength of solid filling and treating compounds under voltage stresses of short duration. It is of value as a comparative test but does not indicate the permanent dielectric strength of these compounds.

(*b*) The dielectric strength of this class of material varies with the temperature. It is, therefore, recommended that a sufficient number of tests be made at different temperatures to establish the momentary dielectric strength-temperature curve from 0 to 100 C.

Sample

34. A representative sample shall be taken from the original package, melted and poured directly into the testing container. Care should be exercised in melting and pouring the compound not to over-

heat it nor to entrap air. A melting and pouring temperature of approximately 50 C. above the softening point (ring-and-ball method) as determined under Section 2 (*b*) is recommended. The electrodes shall be heated to the approximate temperature of the compound before filling the container.

Electrodes

35. (*a*) The testing container, after filling, shall be placed in a suitable constant-temperature air bath or oil bath and sufficient time allowed to elapse to bring the entire mass to a uniform temperature. The temperature shall be determined by a thermocouple attached to one of the metal electrode ends or by a mercury thermometer placed vertically touching an electrode and approximately ½ in. (1.25 cm.) from the gap between electrodes.

(*b*) The test shall be made between polished hemispherical (Note 1) brass or copper electrodes ½ in. in diameter separated by a gap of 0.1 in. (Note 2).

NOTE 1.—A convenient form of apparatus for holding the electrodes and compound is described in Appendix III. It is recognized that when liquid materials are being tested, this method is inconsistent with the Standard Methods of Testing Electrical Insulating Oils (A.S.T.M. Designation: D 117) of the American Society for Testing Materials.[1] However, since spherical electrodes are considered preferable for solid and semisolid materials, the advantage of using spherical electrodes for all splicing compounds, whether liquid or solid, so that direct comparison can be made, is sufficiently great to justify the inconsistency with Methods D 117.

NOTE 2.—In the case of materials which cannot be broken down with the available voltage, the gap may be reduced to 0.05 in. but results will not be comparable directly with those obtained with the 0.1-in. gap.

Testing Transformer Voltage Control and Measurement

36. (*a*) The testing transformer used, methods of voltage control and measurement shall be as outlined in Section 2 of the Tentative Methods of Testing Sheet, Tape and Molded Insulating Materials for Dielectric Strength (A.S.T.M. Designation: D 149-36 T) of the American Society for Testing Materials.[2]

(*b*) The actual gap at the test temperature shall be determined by direct measurement or by measurement at some other temperature and computation of changes due to expansion or contraction.

(*c*) Voltage shall be applied at a value less than 1000 v. and raised at the rate of 1000 v. per sec. until breakdown occurs.

Number of Specimens

37. Five specimens at a given temperature shall be tested and the average value taken as the momentary dielectric strength of the compound at that temperature.

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 1167.

[2] See p. 919.

Report

38. The report shall include the following:

(*a*) The momentary dielectric strength – temperature curve;

(*b*) The individual values of the puncturing voltage and the gap length at the various temperatures.

VOLUME RESISTANCE – TEMPERATURE CHARACTERISTICS

Volume Resistance versus Temperature

39. (*a*) This test is intended to determine the volume resistance – temperature characteristics of solid filling and treating compounds. It is of value as a comparative test and also may be used in determining the volume resistivity on an ohm-centimeter basis.

Temperature Range

(*b*) The volume resistance of this class of material varies with the temperature, generally decreasing rapidly with increase of temperature. It is, therefore, recommended that a sufficient number of tests be made at different temperatures to establish the volume resistance – temperature curve. To be of most significance, the test shall include determinations made up to the highest service temperatures. At room temperatures and below, the volume resistance of practically all of these compounds is so high that it cannot be measured with the ordinary galvanometer equipment.

Conductivity Cell

40. A suitable conductivity cell consisting of parallel planes, concentric cylinders, or coaxial cones shall be used in determining the volume resistance of the compound. The distance between electrodes shall not be less than 0.75 mm. (0.03 in.) nor more than 5 mm. (0.2 in.). The voltage gradient shall not exceed 200 v. per millimeter (5 v. per mil). The area of the electrode shall be sufficiently large so that the current flow can be measured, with the apparatus available, to an accuracy within 5 per cent. Electrode areas of 50 to 500 sq. cm. (7.7 to 77.5 sq. in.) should prove suitable. Because of possible catalytic or corrosion effects of some compounds on certain metals, the electrodes should be nickel, gold or platinum plated.

The insulating material used to support the electrodes shall be capable of withstanding the wide temperature range to which the cell is subjected and preferably shall be of an inorganic material such as a ceramic material or suitable glass.

A test run on the empty cell shall be made over the temperature range chosen in order to determine if any leakage is present.

A conductivity cell that has been found suitable is described in Appendix IV.

Sample

41. (*a*) A representative sample shall be taken from the original package, melted and poured directly into the testing container. Care shall be exercised in melting and pouring the compound not to overheat nor to entrap air in it. A melting and pouring temperature of approximately 50 C. above the softening point (ring-and-ball method) as determined under Section 2 (*b*) is recommended. The quantity of the sample depends upon the capacity of the resistivity cell used, but in any case it shall be sufficient to permit three separate determinations. Before filling, the conductivity cell shall be heated to slightly above the pouring temperature of the compound.

(*b*) A suggested procedure in filling the cell, especially in the case of the higher melting compounds, is to determine the quantity of compound necessary to just fill the cell with the electrodes in position. In the case of coaxial cones or concentric cylinders the proper quantity of the heated compound shall be first poured slowly into the outer cylinder. Any bubbles which may form on the surface of the compound shall be removed by a quick application of a flame from a bunsen burner. Immediately the inner electrode shall be slowly lowered into the compound and a thermometer placed in the well.

Test Procedure

42. The conductivity cell, after filling, shall be placed in an oil or air bath having suitable temperature control and sufficient time allowed to elapse to bring the bath and cell to temperature equilibrium at each test temperature. The temperature of the cell shall be determined by two mercury thermometers placed in contact with the electrodes. The temperature of the bath shall be determined by a mercury thermometer placed near the cell. The temperature of the bath shall be within 1 C. of the test temperature when readings are taken. The temperatures of the cell thermometers shall agree within 0.5 C. of each other and within 1 C. of the bath temperature when readings are taken.

Measurements and Calculations

43. The volume resistance shall be measured at each temperature in accordance with the Standard Methods of Test for Resistivity of Insulating Materials (A.S.T.M. Designation: D 257) of the American Society for Testing Materials,[1] with particular attention to Sections 8, 9, 10, 17, 18 and 19 for liquid insulating materials.

Report

44. The report shall include the following:

(*a*) The type of resistivity cell used;

(*b*) The distance between guarded and unguarded electrodes;

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 1203.

(*c*) The area of guarded electrode;

(*d*) The battery voltage; and

(*e*) A curve plotted from the readings obtained over the temperature range chosen showing the relation of volume resistance in ohm-centimeter units and the temperature in degrees Centigrade.

NOTE.—In lieu of the information required in Paragraphs (*b*) and (*c*), a statement of the approximate overall accuracy may be made.

POWER FACTOR AND DIELECTRIC CONSTANT

Scope

45. This test is intended to determine the power factor and the dielectric constant of solid filling and treating compounds at specified temperatures corresponding to those temperatures to which the materials are to be subjected in service.

Temperature Range

46. Since the power factor and dielectric constant of this class of materials vary with the temperature, a sufficient number of tests shall be made at different temperatures to establish the dielectric constant - temperature curve and the power factor - temperature curve over the temperature range to which the respective material is subjected in service. Determinations shall be made at not less than three temperatures; a temperature near the lowest to which the material is to be subjected in service, ordinary room temperature of 20 to 25 C., and a temperature near the maximum temperature to which it is subjected in service.

NOTE.—For many materials the power factor - temperature curve may have a maximum, minimum, or other irregularity within the working range of temperatures. With such a material many determinations may be required to establish the curve.

Test Specimens

47. The materials to which these tests apply fall into two classes as regards the most suitable type of specimen to be used in the measurement of power factor and dielectric constant. One class includes waxes and other materials which can be cast or pressed into sheet form and then measured between electrodes, such as are used in making tests on porcelain, molded materials and sheet materials. (See the Tentative Methods of Testing Electrical Insulating Materials for Power Factor and Dielectric Constant (A.S.T.M. Designation: D 150 - 36 T) of the American Society for Testing Materials.[1]) The other class includes materials that are fluid at ordinary temperature or can be made so by increasing their temperatures. Materials in the fluid state can be poured into a measuring cell such as described in Section 52 and the determinations made from which the power factor and the dielectric constant can be calculated.

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[1] See p. 955.

Measuring Cell

48. In the measuring cell the distance between the electrodes and the area of the electrodes shall be such that a capacitance of not less than 100 $\mu\mu$f. will be obtainable. The voltage gradient shall not be over 5 v. per mil. Due to the catalytic or corrosive effects of some compounds on certain metals, the electrodes may need to be nickel, gold, or platinum plated. The insulating material used to support the electrodes shall be capable of withstanding the wide temperature range to which the cell or material is to be subjected during the tests without any appreciable effect upon the determinations being made. Certain ceramic materials, special glasses, and quartz have been found suitable for insulating supports for the electrodes between which the material is to be measured. One cell that has been found satisfactory for these determinations is described in Appendix IV. Cells of different construction from the one described have been used with equally satisfactory results.

Sampling

49. A representative sample shall be taken from the original package, melted if necessary, and then either cast in the form of a disk or poured directly into the measuring cell. The use of the cell or the disk will depend upon the particular material. In heating and pouring the compound, care shall be exercised not to entrap air in the compound between the electrodes. A melting and pouring temperature of approximately 50 C. above the softening point (ring-and-ball method, as determined under Section 2 (*b*)) is recommended. A sufficient quantity of the material shall be taken as the sample to enable making at least three determinations. Before pouring the compound into the container or cell, the container or cell shall be heated to a temperature slightly higher than the temperature at which the compound is being poured.

Temperature Bath

50. The specimen as prepared above, shall be placed in an oil or air bath having suitable temperature control, and sufficient time allowed to elapse to bring the bath and specimen to the desired temperature equilibrium at each test temperature. The temperature of the electrodes and the compound shall be determined by two mercury thermometers, or two thermocouples with cold junctions placed in contact with the electrodes. The temperature of the bath shall be determined by a thermometer, or a thermocouple with cold junction placed near the cell or the specimen. The temperature of the bath shall be within 1 C. of the desired test temperature when the

determinations are made. The temperature of the specimen thermometers or thermocouples shall agree within 0.5 C. of each other and within 1 C. of the bath temperature when the readings are taken.

Measurements

51. Determinations shall be made of the power factor and dielectric constant at the temperatures and frequencies desired in accordance with the methods outlined for 25 to 60 cycles, 1000 cycles and 100 to 1500 kilocycles as described in the Tentative Methods of Testing Electrical Insulating Materials for Power Factor and Dielectric Constant (A.S.T.M. Designation: D 150 - 36 T) of the American Society for Testing Materials.[1] Measurements shall be made at the frequencies to which the material will be subjected in service unless otherwise specified. When using a cell in making power factor and dielectric constant determinations, measurements shall be made at the temperature desired, first with air as dielectric and then with the compound in the cell as dielectric.

Calculations

52. The power factor shall be calculated in accordance with the Tentative Methods D 150 - 36 T,[1] and the dielectric constant shall be determined for any given compound from the ratio of the capacitance of the cell with the compound as dielectric to the capacitance of the cell with air as dielectric. When the specimen under determination is in the form of a disk the air capacitance shall be calculated from the dimensions of the electrodes and the thickness of the dielectric. In this case, correction shall be made as outlined in the Tentative Methods D 150 - 36 T.[1] When the sample has been poured between electrodes being held apart by separators, the air capacitance can be measured directly the same as with the cell, or it may be calculated from the dimensions of the electrodes and the thickness of the separators, taking into account the edge correction.

Report

53. The report shall include the following:

(*a*) The type of cell used and the dimensions of the same.

(*b*) The method used and the frequency at which measurements were made.

(*c*) The voltage across the specimen during the test.

(*d*) The dielectric constant, the power factor, and the respective temperatures at which the determinations were made.

(*e*) A statement of the approximate accuracy of the determinations.

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[1] See p. 955.

APPENDIX I

DEGASIFICATION OF SOLID FILLING AND TREATING COMPOUNDS

Compounds having high viscosity may be degasified by heating in a vacuum oven or in a cell fitted with a special cover with vacuum connection similar to the cover shown in Fig. A1, Appendix II.

In either method the temperature and vacuum should be high enough and the time long enough to insure the driving off of mechanically entrapped gases, but should tend to decompose the compound as little as possible. A gas-free condition is indicated when bubbles of gas no longer appear at the surface of the compound.

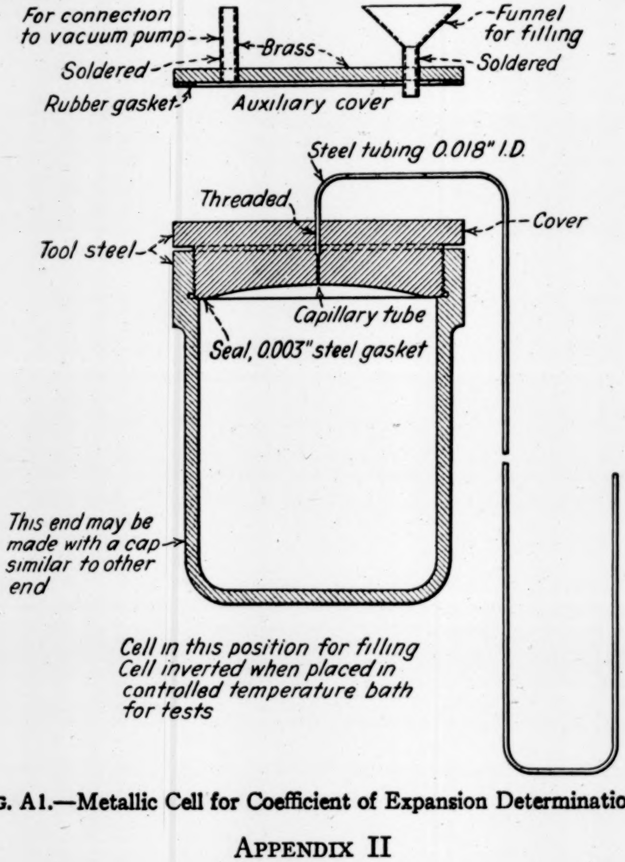
For connection to vacuum pump
Brass
Funnel for filling
Soldered
Soldered
Rubber gasket
Auxiliary cover
Steel tubing 0.018" I.D.
Threaded
Cover
Tool steel
Capillary tube
Seal, 0.003" steel gasket
This end may be made with a cap similar to other end
Cell in this position for filling
Cell inverted when placed in controlled temperature bath for tests

FIG. A1.—Metallic Cell for Coefficient of Expansion Determinations.

APPENDIX II

CELL FOR DETERMINING COEFFICIENT OF EXPANSION OF SOLID FILLING AND TREATING COMPOUNDS

Figure A1 shows the metallic cell for coefficient of expansion determinations. The cell consists of four principal parts: A steel cylinder, a metallic gasket, a steel cover, and a dummy or auxiliary cover for filling. The gasket must be of a metal which does not amalgamate with mercury.

The cylinder is about 2.5 in. (6.35 cm.) in internal diameter, and approximately 3 in. (7.6 cm.) in internal depth. The top of the cylinder is threaded to receive the steel cover and has a machined shoulder to seat a 0.003 in. thick metallic gasket. The cylinder may be of one piece construction or fitted with a cap at the bottom similar to the top end.

The steel cover is carefully rounded on the under side to avoid air pockets. It is threaded into the top of the cylinder and seats on the metallic gasket. The center of the cover is threaded to receive a steel capillary tube of 0.018 in. in internal diameter.

The auxiliary cover is brass with a rubber gasket seated by atmospheric pressure. A brass funnel and vacuum connection are soldered to the cover. A plug is provided for sealing the funnel while the cell is maintained under the vacuum specified after filling.

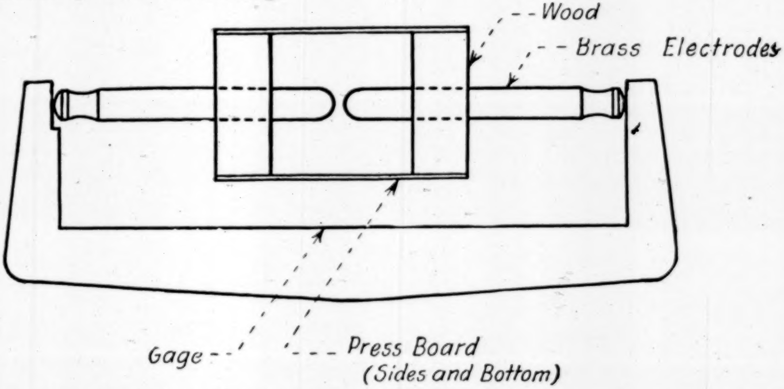

FIG. A2.—Container, Showing Electrodes in Place for Dielectric Strength Test.

APPENDIX III

DEVICE FOR DETERMINING DIELECTRIC STRENGTH OF SOLID FILLING AND TREATING COMPOUNDS

Because of the great difficulty experienced in removing most solid filling and treating compounds from the container and from the electrode an arrangement is desirable which is sufficiently inexpensive to permit of its being discarded fully or in part after the test. Two devices that have proved satisfactory are illustrated in Figs. A2 and A3.

Figure A2 shows the simplest device. It consists of a box about 2 in. square in cross-section and 2 in. in length inside of the wooden ends. The sides and bottom are made from a single piece of press board and are attached to wooden blocks which form the ends. Holes drilled through the wooden blocks receive the electrodes which are turned from ½ in. diameter brass rod. To facilitate adjustment of the gap length, a gage is arranged to slip over the ends of the electrode and so regulate the gap to the desired value.

Figure A3 shows a more elaborate type of testing device consisting of a framework made from laminated phenol fiber about 8 in. (20 cm.) in length and 2¼ in. (5.7 cm.) square with brass bushings centrally inserted in each end member to hold the electrode rods. A box of heavy paper or pasteboard is arranged to fit loosely inside the framework. The electrodes, which are separable by means of screw joints, are inserted through small holes in the ends of the paper box and clamped to make an oil-tight joint. The proper electrode spacing may be obtained by means of an adjusting screw on the right-hand end. Changes in the electrode spacing with temperature can be reduced greatly (to less than 0.001 in. in a change of temperature of 75 C.) by the indicated electrode design.

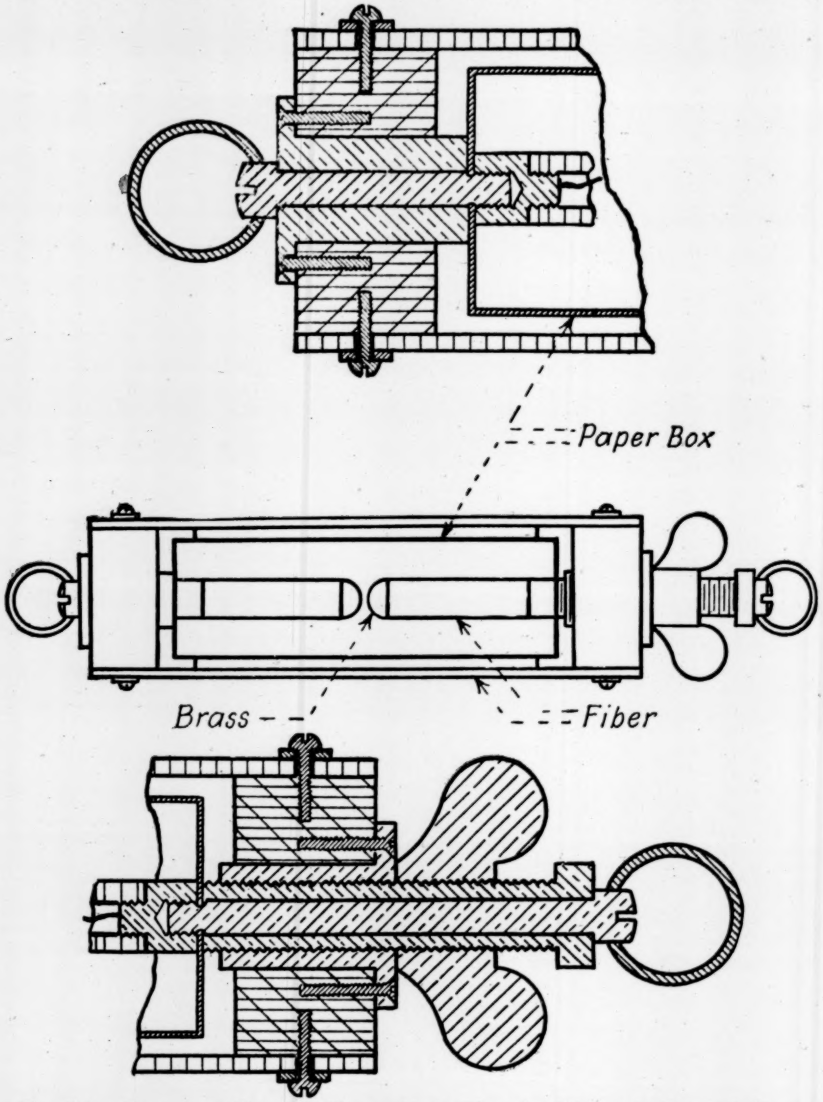

FIG. A3.—Container, Showing Electrodes in Place for Dielectric Strength Test.

Phenol fiber of suitable coefficient of expansion is used for supporting the brass hemispherical electrode tips and electrical connection is made by a copper wire through the center of the fiber rod. The volume of the container may be reduced to accommodate small samples by the insertion of wedges of carefully dried wood into the corners of the paper box.

APPENDIX IV

MEASURING CELL FOR RESISTIVITY, POWER FACTOR AND DIELECTRIC CONSTANT MEASUREMENTS OF SOLID FILLING AND TREATING COMPOUNDS

A conductivity cell that has been developed for the purpose of measuring the volume resistivity as well as other electrical constants of solid filling and treating compounds and oil is shown in Fig. A4. The concentric cylinder type of cell was chosen after experimenting with various types for the following points of simplicity and efficiency:

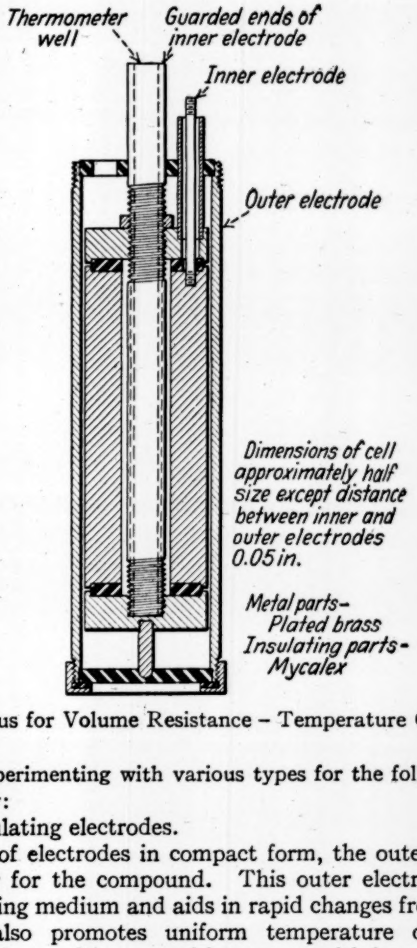
Thermometer well
Guarded ends of inner electrode
Inner electrode
Outer electrode
Dimensions of cell approximately half size except distance between inner and outer electrodes 0.05 in.
Metal parts- Plated brass
Insulating parts- Mycalex

FIG. A4.—Apparatus for Volume Resistance - Temperature Characteristics Test.

1. Ease of insulating electrodes.
2. Large area of electrodes in compact form, the outer one of which also serves as container for the compound. This outer electrode is also exposed directly to the heating medium and aids in rapid changes from one temperature to another and also promotes uniform temperature distribution to the comparatively thin layer of compound in contact with it.
3. Comparative ease in assembling and disassembling cell and cleaning.

This type of cell permits the use of a very small amount of insulating material to insulate the electrodes. Mycalex has been found to be a satisfactory material for this purpose due to the fact that it can be machined to size and has good insulation resistance characteristics over the temperature range at which these compounds are normally tested. Also, it apparently is unaffected by the solvents used in the cleaning operation.

A suggested method of cleaning the cell is to remove the bottom retaining ring and to hang the cell in an oven by a hook fastened through a hole drilled in the protruding stem. Upon heating, the outer cylinder will slide away from the inner electrode and both parts will drain fairly clean of the compound. In order to speed up this cleaning, the flame of a bunsen burner may be applied directly to the cell after removing the cap and suspending the cell by the protruding stem. Further application of the flame to the cylinder and inner electrode after they separate will rapidly remove most of the compound and the final cleaning of each part can be accomplished by suitable solvents.

TENTATIVE METHODS OF TEST
FOR
CONDUCTING PATHS IN ELECTRICAL SLATE[1]

A.S.T.M. Designation: D 273 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1927; REVISED, 1936.

These methods include two procedures for testing electrical slate for conducting paths or veins. The general fields of application and limitations of the two procedures are described in the sections on scope which precede each of the methods. Both methods are non-destructive and may thus be used for routine factory or quarry inspection work.

METHOD A

Scope

1. This method employs high voltage at very high frequencies obtained from a simple spark coil. Numerical readings are not obtainable with this test procedure, but it can be depended on to locate conducting paths or veins with considerable certainty and will, furthermore, give a rough, comparative indication of the impedance of the slate. It is recommended primarily as a routine factory or quarry test, and since the apparatus required is very simple and inexpensive, it is applicable even where a comparatively small quantity of slate is to be tested. If the spark coil employed is of ordinary size, this method is much less hazardous to the operator than any method (such as Method B below) which employs high voltage at commercial frequencies.

Apparatus

2. The apparatus shall consist of the following:

(*a*) *Spark Coil.*[2]—A spark coil of the vibrator type capable of giving a spark from $\frac{3}{8}$ to 1 in. in length between needle points.

(*b*) *Current Source.*—Six volts direct current.

NOTE.—An automobile-type storage battery of about 100-amp. hr. capacity is suggested.

(*c*) *Electrodes.*—One electrode shall be either a sharp-pointed No. 8 B & S gage bare copper wire, about 4 in. in length, mounted on the end of a hard rubber rod about 1 in. in diameter and 1 ft. in length or a multiple-point comb type electrode mounted on a similar hard rubber rod as shown in Fig. 1. The comb type electrode permits the exploration of large areas more rapidly than the single-point electrode. The electrode used shall be connected to the high tension side of the spark coil with high grade automobile ignition wire, or equivalent, not more than 10 ft. in length.

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-9 on Electrical Insulating Materials.

[2] A Model T Ford ignition-type spark coil has been found satisfactory.

The other electrode shall be a sheet of metal of suitable size on which the slate under test can be laid. This shall be connected to the other terminal of the spark coil which shall be grounded.

Test Specimen

3. The test specimens may be of any size and shall have all surfaces, including edges, sand-rubbed or hone finished.

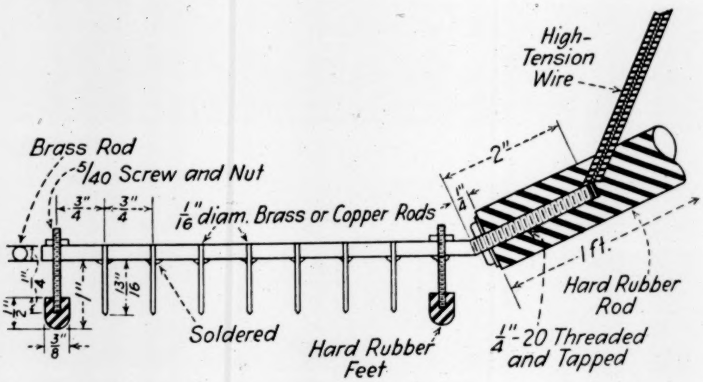

FIG. 1.—Suggested Multiple Point Electrode for Exploring Slate for Conducting Paths and Veins by the Spark Coil Method.

Test Standard

4. A test standard consisting of a sheet of electrical slate of a quality to be agreed upon between the purchaser and manufacturer shall be used. This standard may be of any convenient size such as ½ by 12 by 12 in.

Conditioning

5. No conditioning of the test standard or the test specimen is ordinarily required, if the surfaces appear dry. As surface moisture tends to increase the brush discharge, wet samples shall be dried in an oven at 150 F. (65 C.) for at least 16 hr. before testing.

Procedure

6. (*a*) With both electrodes connected to the spark coil and while supporting the pointed ungrounded electrode by the insulating handle, the spark coil vibrator shall be adjusted to give as smooth and steady a tone as possible. The pointed ungrounded electrode shall then be brought within about ⅜ to 1 in. (depending upon the capacity of the coil used) of the plate electrode, and a continuous spark discharge should take place.

(*b*) The test standard and test specimen shall be laid side by side on the grounded electrode and the pointed electrode brought to within about $\frac{1}{4}$ in. of the face of the standard. Under this condition a small amount of typical bluish brush discharge will be noted at the point. The test specimen shall then be carefully explored over its entire face and edges with the pointed electrode, holding it about $\frac{1}{4}$ in. from the surfaces of the test specimen. In the case of the comb type electrode, the correct spacing between the points and the surface is definitely fixed. When a conducting vein or path is located, sparks will jump and scatter to it in lightning-like forks over the surface of the specimen (Note). Slate that shows conducting paths or veins under this test is unsatisfactory for electrical purposes and shall be rejected.

NOTE.—The intensity of the brush discharge depends in general on the impedance of the slate, that is, the lower the impedance the greater the brush discharge. Unless the slate is to be used in apparatus where practically any leakage is objectionable, slight increase in the brush discharge noted on the specimen as compared with that on the standard is permissible, provided, however, that it is essentially uniform over the entire area of the specimen. Such an increase in the brush discharge must not be confused with the sparks which occur when an actual conducting vein is approached. Once observed, this latter sparking is unmistakable as it will be of marked intensity both visibly and audibly and will tend to branch out in many directions. The veins are sometimes confined to narrow ribbon-like boundaries that run the full length of the specimen. Others are more generally distributed and in these cases the spark discharge sometimes will enter the surface at one point, emerge at another and re-enter again at still another indicating the presence of substrata conducting paths.

METHOD B

Scope

7. This method is primarily recommended where numerical readings are considered necessary. Fundamentally, this procedure measures the leakage current when the slate is subjected to a high voltage of commercial frequency. It requires a moderate outlay for apparatus and unless surrounded by proper safeguards should be used only by an operator experienced in working with high voltages. It is thus primarily a laboratory method but is applicable to routine factory or quarry inspection service where the volume of slate to be tested is sufficiently great to justify the expense of the apparatus and of providing suitable safeguards.

Apparatus

8. The apparatus shall consist of the following:

(*a*) *Transformer.*—A testing transformer rated at 1 kva. or larger, high-voltage winding for 10,000 v., provided with a middle tap.

(*b*) *Ammeters.*—Two similar alternating-current ammeters having a range of 200 or 250 ma.

(*c*) *Current Source.*—A source of alternating current having a frequency of 60 cycles per second, of approximately sine-wave shape, and of a voltage suited to the primary winding of the testing transformer.

(*d*) *Electrodes.*—The electrodes shall consist of two metallic disks each having a contact area of not less than 2 sq. in., mounted in insulating handles for the effective protection of the operator, and a plate electrode as wide and of the same length as the specimen to be tested. If the plate electrode cannot be conveniently made as long as the specimen, then the specimen shall be tested in sections until its entire area has been covered (see Note 2, Section 12).

Test Specimen

9. The test specimens may be of any size, and shall have all surfaces, including edges, sand-rubbed or hone finished.

Conditioning

10. No conditioning of the test specimen is ordinarily required. As surface moisture tends to increase the leakage current, wet samples shall be dried in an oven at 150 F. (65 C.) for at least 16 hr. before testing.

Procedure

11. (*a*) The electrodes shall be connected with the ammeters, and these in turn with the high-voltage terminals of the testing transformer, by flexible cables provided with insulation suitable for continuous use at 10,000 v. The ammeters likewise shall be suitably insulated from ground for operation at 10,000 v. and shall be screened or guarded against accidental contact by the operator.

(*b*) The plate electrode shall be connected to the midpoint tap of the test transformer.

(*c*) The primary of the transformer shall be connected to the current source through a series resistor or reactor which will limit the high-tension current under short-circuit to not more than 0.25 amp. The applied voltage shall be adjusted until the open-circuit voltage of the high-tension winding is 10,000 v.

Leakage Currents

12. The leakage currents of the test specimen as shown by the ammeters shall be noted for the following two tests:

(*a*) With the specimen lying on the plate electrode, both faces of the specimen shall be gone over with the disk electrodes held approximately, but not less than, 2 in. apart. Observation shall be made of the deflection of both ammeters. (Notes 1 and 2.)

(*b*) The specimen shall be stood on edge on the plate electrode and the two movable electrodes shall be moved over the edges of the specimen with attendant observation of both ammeters (Note 1).

NOTE 1.—It is necessary that observation be made of both ammeters since the presence of a conducting path may result in the deflection of either or both instruments, depending on the course which the path takes.

NOTE 2.—Where a considerable number of specimens are to be examined for conducting paths and the factory arrangements are such that these can be moved forward on some type of conveyor, it may be possible to examine the specimens in transit. To this end it will be necessary to provide two sliding or rolling upper electrodes. The lower metal plate electrode, 6 in. broad or more, shall be so placed that the specimen to be examined will pass over it. The two upper electrodes, of the sliding or rolling type, shall be spaced approximately, but not less than, 2 in. apart, and extend in parallel lines across the specimen at a suitable height and so placed with respect to the lower electrode as to make contact with the upper surface of the specimen in the region which is passing over the lower electrode.

TENTATIVE METHODS OF TEST
FOR
THICKNESS OF SOLID ELECTRICAL INSULATION[1]

A.S.T.M. Designation: D 374 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1933; REVISED, 1934, 1936.

Scope

1. (*a*) These methods are intended to determine the thickness of solid insulating materials, except rubber insulating tape which should be tested in accordance with Tentative Specifications and Tests for Rubber Insulating Tape (A.S.T.M. Designation: D 119 – 35 T) of the American Society for Testing Materials,[2] and friction tape for electrical purposes which should be tested in accordance with the Tentative Specifications and Tests for Friction Tape for General Use for Electrical Purposes (A.S.T.M. Designation: D 69 – 36 T) of the American Society for Testing Materials.[3]

Alternative Procedures, Methods A and B

(*b*) Two alternative procedures, Methods A and B, are described. In Method A the use of an adjusted ratchet micrometer and a definite manipulative procedure controls the pressure exerted on the specimen. In Method B a micrometer without ratchet is used and pressure on the specimen is controlled by stopping closure of the micrometer when resistance to movement of the specimen between the instrument faces is first observed.

Precision of Methods

(*c*) Method B is used generally for routine measurements. Method A, which may also be used for routine measurements, is preferable in cases of dispute. The precisions of the two methods are as follows:

For unyielding materials, such as porcelain and laminated or molded phenolic materials, the maximum error of either method is of the order of 0.5 mil or less.

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-9 on Electrical Insulating Materials.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1110 (1935); also 1936 Book of A.S.T.M. Tentative Standards, p. 1054.

[3] See p. 1059.

For compressible materials, such as paper, fabric or leather, the maximum error of Method A is of the order of 0.5 mil. By applying the proper technique, Method B will give an accuracy of the order of 0.5 mil for the usual thicknesses of resilient materials encountered in the trade, except that for materials which are very compressible, the error may be somewhat greater.

Method A

Apparatus

2. The instrument used for determining thickness by Method A shall be a 1-in. machinist's type micrometer without a locking device. It shall be constructed with a vernier reading to 0.1 mil (0.0001 in.) and with a ratchet or similar mechanism for controlling measuring pressure, and shall have anvil and spindle surfaces 0.250 in. ± 0.001 in. in diameter. The instrument shall conform to the requirements for flatness and parallelism of micrometer surfaces, zero reading, wear of micrometer screw, micrometer screw error tolerances and ratchet pressure specified in Section 6 (*d*), (*e*), (*f*), (*g*), (*h*) and (*i*). The micrometer shall be tested and calibrated periodically for conformity to these requirements.

Procedure

3. Before starting measurements of thickness the micrometer shall be closed on the specimen at a location outside the area to be measured. The micrometer shall then be opened not more than 4 or 5 mils (0.004 or 0.005 in.) and then moved into the area selected for measurement. Using the ratchet, the micrometer surfaces shall be closed so slowly on the specimen that the mil scale divisions may be easily counted as they move past the reference mark, or at a rate of about 2 mils (0.002 in.) per second. The closing motion shall be continued at the same rate until the ratchet has clicked three times, and then the thickness shall be read by means of the vernier.

In moving from one measurement location to another this operation shall be repeated, never opening the micrometer more than 4 or 5 mils (0.004 or 0.005 in.) more than the specimen thickness.

Method B

Apparatus

4. The instrument used for determining thickness by Method B shall be a 1-in. machinist's type micrometer without a locking device. It shall be constructed with a vernier reading to 0.1 mil (0.0001 in.) and with anvil and spindle surfaces 0.250 in. ± 0.001 in. in diameter. The instrument shall conform to the requirements for flatness and parallelism of micrometer surfaces, zero reading, and micrometer screw

error tolerances specified in Section 6 (*d*), (*e*), (*f*) and (*h*). The micrometer shall be tested and calibrated periodically for conformity to these requirements.

Procedure

5. In the determination of thickness the micrometer specified in Section 4 shall be slowly closed on the specimen until contact is made, without appreciable distortion of the specimen. The criterion of contact is the initial development of frictional resistance to movement of the specimen between the micrometer surfaces. The thickness shall then be read by means of the vernier.

In moving from one measurement location to another this operation shall be repeated, never opening the micrometer more than 4 or 5 mils (0.004 or 0.005 in.) more than the specimen thickness.

MICROMETER REQUIREMENTS

Cleaning Micrometer Surfaces

6. (*a*) Before and during instrument calibration and thickness measurements, the micrometer surfaces shall be maintained in a clean condition by lightly closing them on a clean sheet of smooth bond paper and moving the paper between the surfaces. To minimize the danger of the presence of lint, the edge of the paper should not be pulled between the surfaces.

Calibrating Method A Micrometer

(*b*) The manipulative procedure for calibrating controlled pressure instruments used in Method A, shall be in accordance with the following:

The micrometer shall be closed on the gage or calibrating device and then opened 4 or 5 mils (0.004 or 0.005 in.). Using the ratchet, the micrometer shall be again closed so slowly on the calibrating device that the mil scale divisions may be easily counted as they move past the reference mark, or at the rate of about 2 mils (0.002 in.) per second. The closing motion shall be continued at the same rate until the ratchet has clicked three times, when the reading shall be taken.

Calibrating Method B Micrometer

(*c*) The manipulative procedure for calibrating instruments used in Method B shall be in accordance with the following:

The micrometer shall be slowly closed on the gage or calibrating device until contact of the surfaces and gage is made. The criterion of contact is the initial development of frictional resistance to movement of the gage device between the micrometer surfaces.

Flatness of Micrometer Surfaces

(*d*) The anvil and spindle surfaces of the micrometer shall be flat to within 0.00005 in. The flatness may be determined by use of an optical flat, as follows:

After cleaning the surfaces of the flat and the micrometer (Paragraph (*a*)) the latter shall be closed on the flat as described in Paragraph (*b*) or (*c*). When illuminated by diffused daylight, interference bands are formed between the surfaces of the flat and those of the micrometer. The location, shape and number of these bands indicates the deviation from flatness in increments of half the average of the wave lengths of white light, which is taken as 0.00001 in.

A *flat surface* forms straight, parallel and equidistant fringes.

A *grooved surface* forms straight parallel fringes at unequal intervals. The estimated maximum displacement of any line from its normal position, where all lines would be equidistant, is a measure of deviation from flatness.

A *symmetrical concave or convex surface* forms concentric circular fringes, and their number is a measure of deviation from flatness.

An *unsymmetrical concave or convex surface* forms a series of curved fringes, cutting the periphery of the micrometer surface. The number of fringes cut by a straight line connecting the termini of any fringe is a measure of the deviation from flatness.

Parallelism of Micrometer Surfaces

(*e*) The anvil and spindle surfaces of the micrometer shall be parallel to each other to less than 0.0001 in. when tested with a pair of screw-thread-pitch wires or with a pair of $\frac{1}{4}$-in. nominal diameter plug gages. The diameters of the screw-thread-pitch wires or the plug gages, accurate to 0.00002 in., shall differ by an amount approximately equal to the axial movement of the spindle when rotated through 180 deg. (12.5 mils). The micrometer shall be closed on the wires or on the plug gages according to the procedure described in Paragraph (*b*) or (*c*). Observations made with either wire or with either plug gage placed at any location between the surfaces shall show differences of less than 0.0001 in.

Zero Reading

(*f*) The position of the anvil shall be such that a zero reading is obtained when the micrometer is closed on the anvil as described in Paragraph (*b*) or (*c*). Ten trials shall give ten readings of zero. The condition of zero reading is satisfied when examinations with a low-power magnifying glass show that at least two-thirds of the widths of the zero graduation on the barrel and that of the reference mark coincide with each other.

Wear of Micrometer Screw

(*g*) The device for compensating for wear of the micrometer screw shall be adjusted so that the spindle has no perceptible lateral or longitudinal looseness and yet may be rotated with a torque load of not more than ¼ in.-oz.

Micrometer Screw Error

(*h*) The micrometer screw error, after zero adjustment is made, shall be checked at 2, 5, and 10 mils, and at intervals of 100 mils over the remaining graduated scale. For checks up to and including a thickness of 10 mils, selected gage blades the thicknesses of which are known to ±0.00002 in. shall be used. Checks at values greater than 10 mils shall be made with standard gage blocks. At each value checked, ten readings shall be taken and the arithmetic mean of these ten readings shall not differ from the thickness of the gage used by more than 0.1 mil (0.0001 in.). Manipulation of the instrument in these checks shall be in accordance with Paragraph (*b*) or (*c*).

Ratchet Pressure

(*i*) The ratchet shall be so adjusted that a pressure of not more than 27 nor less than 23 lb. per sq. in. is developed when the spindle surface is contacted with a polished steel surface as described in Paragraph (*b*).

TENTATIVE METHODS OF TESTING VARNISHED CLOTHS AND VARNISHED CLOTH TAPES USED IN ELECTRICAL INSULATION[1]

A.S.T.M. Designation: D 295 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1928; REVISED, 1929, 1932, 1933, 1934, 1936.

Scope

1. These methods are intended to apply to varnished cloths and varnished cloth tapes to be used as electrical insulation and are directly applicable to both the "straight-cut" and "bias-cut" materials, unless otherwise stated in the method.

SAMPLING

Selecting Rolls

2. (*a*) Shipments of varnished cloth and varnished cloth tapes shall be sampled as specified in Paragraphs (*b*) and (*c*). The rolls or pads shall be selected in such a manner as to be representative of the shipment.

(*b*) *Cloth.*—One roll shall be selected from each ten rolls in a shipment of full-width varnished cloth. The minimum number of rolls selected from any shipment shall be two.

(*c*) *Tape.*—At least one roll or pad shall be selected from each 1000 rolls or pads in a shipment of varnished cloth tape. The minimum number of rolls or pads selected from any shipment shall be ten.

Selecting Samples

3. (*a*) Except for tape shipped packed in oil, not less than two turns of cloth or six turns of tape from each roll or pad selected for sampling shall be torn off and discarded before the samples are selected. The number of samples required for purposes of test shall then be cut across the entire width of each roll or pad. The length of the samples shall not be less than 91.44 cm. (36 in.) for straight-cut material; from seam to seam for sewed bias-cut material; and from jointed-selvage to jointed-selvage for seamless bias-cut material.

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[1] **Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-9 on Electrical Insulating Materials.**

NOTE 1.—Specimens of bias-cut materials cut from the above samples shall exclude seams and jointed-selvages from the test areas.

NOTE 2.—If it is desired to test the seams or jointed-selvages for tensile breaking strength, additional specimens will have to be cut so that the seams or jointed-selvages are in the center of the specimens.

(*b*) From shipments such as sheets of cloth or strips of tape, the samples shall be representative of the shipment and shall be taken in accordance with Paragraph (*a*).

CONDITIONING

Conditioning

4. (*a*) The roll of cloth or tape from which specimens are to be cut shall be conditioned for a minimum of 2 hr. at a room temperature between the limits of 20 to 30 C., no humidity control.

(*b*) Specimens for tensile breaking strength, elongation, and dielectric strength "as received" shall be removed from the roll as required and tested immediately.

(*c*) If the room humidity is above 65 per cent, the roll of tape shall be kept in a cabinet whose relative humidity is maintained between 60 to 65 per cent.

(*d*) In the event of dispute, the test specimens shall be conditioned for 48 hr. at a temperature between 20 to 30 C. and at a relative humidity between 60 to 65 per cent.

THICKNESS

Apparatus

5. The thickness shall be measured in accordance with Method B of the Tentative Methods of Test for Thickness of Solid Electrical Insulation (A.S.T.M. Designation: D 374 – 36 T) of the American Society for Testing Materials.[1]

Specimens

6. Specimens for test shall consist of samples selected in accordance with Section 3.

Procedure

7. In making thickness measurements, only one layer of material shall be used.

Number of Measurements

8. (*a*) In the case of cloths, ten measurements equally spaced across the width of the specimen shall be taken and the thickness of the cloth shall be the average of the ten measurements.

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[1] See p. 1026.

(*b*) In the case of tapes, unless otherwise specified, ten measurements equally spaced along the length of each specimen shall be taken and the thickness of the tape shall be the average of the ten measurements.

NOTE.—The average thickness, as obtained in Section 15 for the dielectric strength test, may be conveniently used instead of the separate test described above.

Report

9. The report shall include the average, maximum, and minimum thicknesses in inches.

TENSILE BREAKING STRENGTH

Apparatus

10. (*a*) A testing machine[1] of the dead-weight pendulum type shall be used. The machine shall preferably be power driven.

(*b*) The capacity of the machine shall not exceed 113 kg. (250 lb.).

(*c*) The machine shall be graduated to read 1 lb. or 1 kg. or less per scale division for testing specimens breaking at 22.7 kg. (50 lb.) or over, and to 0.5 lb. or 0.5 kg. or less for testing specimens breaking under 22.7 kg. (50 lb.).

Test Specimens

11. Specimens cut from the full width cloth or from tapes over 2.54 cm. (1 in.) in width shall be 2.54 cm. (1 in.) in width and not less than 35.54 cm. (14 in.) in length. For tape having a nominal width of 2.54 cm. (1 in.) or under the specimens shall be of the original width and shall be not less than 35.54 cm. (14 in.) in length.

NOTE.—If it is desired to test the seams or jointed-selvages of bias-cut materials for tensile breaking strength, specimens obtained as described in Note 2 to Section 3 (*a*) shall be clamped in the testing machine so that the seams or jointed-selvages are midway between the two jaws. When testing, all readings obtained when the specimen breaks away from the seam or jointed-selvage shall be rejected.

Number of Specimens

12. (*a*) In the case of straight-cut cloths, ten specimens shall be cut in the direction of the warp threads and ten in the direction of the filling threads from samples selected in accordance with Section 3.

(*b*) In the case of bias-cut cloths, ten specimens shall be cut in the direction of the length from samples selected in accordance with Section 3.

(*c*) In the case of tapes, one specimen shall be cut from each roll selected in accordance with Section 2 (*c*).

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[1] This apparatus is the same as that used for the testing of paper and described in Section 16 of the Tentative Methods of Testing Untreated Paper Used in Electrical Insulation (A.S.T.M. Designation: D 202 - 36 T), see p. 936.

Procedure

13. (*a*) The ratio of the clearance distance between jaws to the width of the specimen shall not be less than 5 to 1 nor more than 10 to 1.

(*b*) The rate of travel of the movable jaw shall be constant and preferably 30.5 cm. (12 in.) per minute, but it may be within the limits of 28 cm. (11 in.) and 33 cm. (13 in.) per minute provided it is constant.

(*c*) All readings obtained when the specimen breaks at or in the jaws shall be rejected.

Report

14. (*a*) The tensile breaking strength of a roll shall be the average of the breaking loads of all the specimens from the roll. The report shall include the average, maximum, and minimum breaking loads in kilograms or pounds together with the width of the specimens and the nominal thickness.

(*b*) In the case of straight-cut cloths, the tensile breaking strength of the warp threads and the filling threads shall be reported separately.

DIELECTRIC STRENGTH

Method

15. (*a*) The dielectric strength shall be determined in accordance with the Tentative Methods of Testing Sheet, Tape, and Molded Insulating Materials for Dielectric Strength (A.S.T.M. Designation: D 149 – 36 T) of the American Society for Testing Materials,[1] except that the voltage on the specimen shall in all cases be increased at the uniform rate of 0.5 kv. per second up to breakdown.

(*b*) Dielectric strength tests may be applied to specimens of the material as received and on specimens from the elongation and resistance to oil and heat tests.

Specimens

16. (*a*) In the case of cloths, a specimen at least 10.16 cm. (4 in.) in width shall be cut diagonally from corner to corner from a sample selected in accordance with Section 3.

(*b*) In the case of tapes, the specimens shall be samples selected in accordance with Section 3.

Report

17. The report shall include the following:

(*a*) The method used for making the dielectric strength tests,

(*b*) The average dielectric strength in volts per mil and any other values of dielectric strength as required by the materials specifications, and

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[1] See p. 918.

(*c*) The temperature at which the tests were made.

ELONGATION

(*In the Case of Bias-Cut Material*)

Scope

18. This method is intended to determine the effect of mechanical tension on bias-cut varnished cloths and tapes. This test is not applicable to tapes of less than 1.27 cm. (0.5 in.) in nominal width.

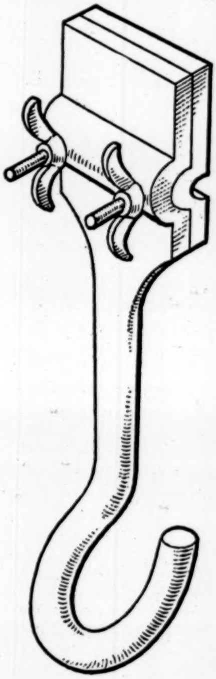

FIG. 1.—Clamp for Elongation Test.

Apparatus

19. The apparatus required for the test shall consist of a pair of clamps for gripping the ends of the specimen. The clamps shall not be less than 5.08 cm. (2.0 in.) in width and one shall be provided with means for attaching to a fixed support and the other with means for affixing suspended weights. See Fig. 1 for suggested form of clamp.

Specimens

20. (*a*) In the case of bias-cut cloths, specimens shall be cut in the direction of the length from the samples selected in accordance

with Section 3. They shall not exceed 3.81 cm. (1.5 in.) in width and shall be at least 91.44 cm. (36 in.) in length.

(*b*) In the case of bias-cut tapes, specimens shall be samples selected in accordance with Section 3 and they shall not exceed 3.81 cm. (1.5 in.) in width. Tapes of greater width than this shall be cut to 3.81 cm. (1.5 in.) or less before testing.

NOTE.—Strips of "Scotch tape" make a satisfactory method for marking the gage length on the elongation test specimens.

Elongation

21. A gage length of 50 cm. shall be marked on the test specimen and the specimen shall be fastened between two suitable clamps so that the gage length is centrally located between the clamps. The clearance distance between each gage line and the adjacent clamp shall be not less than 10 cm.

The test specimen shall be weighted with a specified load, M, (including the weight of the clamp) and at the end of 35 minutes the distance, L, between gage lines shall be measured and the load then removed.

Calculation

22. The percentage elongation is defined by the following formula:

$$\text{Elongation, per cent} = \frac{L - 50}{50} \times 100$$

in which L is in centimeters.

Dielectric Strength

23. After at least 20 min., but not more than 1 hr., following the removal of the load, five puncture voltages shall be taken within the gage length of the specimen in accordance with Section 15, using only Method A of the Tentative Methods D 149 – 36 T.[1] The dielectric strength shall be calculated on the basis of the average thickness of the specimen determined immediately before the dielectric breakdown test.

Report

24. The report shall include the following:

(*a*) the load in pounds per inch width of tape;

(*b*) the percentage elongation;

(*c*) the average dielectric strength in volts per mil after elongation; and

(*d*) the temperature of the room during the elongation test.

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[1] See p. 918.

RESISTANCE TO OIL

Scope

25. This method is intended to determine the effect of oil on the varnish film and dielectric strength of the cloths or tapes.

Specimens

26. One specimen 30.48 cm. (12.0 in.) in length and not exceeding 3.81 cm. (1.5 in.) in width shall be cut from each of the rolls selected in accordance with Section 2.

Procedure

27. The specimens shall be immersed for 15 min. in a specified oil maintained at a temperature of from 97 to 103 C. At the end of this time, the specimens shall be removed from the oil, allowed to cool for at least 30 min. to room temperature and any excess oil removed by placing between blotters without any sliding.

Examination

28. The varnish film shall be examined for disintegration in the oil and flaking either in the oil or on the blotter. Disintegration in the oil may be detected by examination of the used oil for turbidness.

NOTE.—The oil may be considered turbid if a sample of used oil filtered through filter paper is distinctly less transparent than an unfiltered sample of the unused oil when the two samples, in identical containers, are held in front of a diffused light. Flaking along the cut edges of tapes shall not be considered as disintegration of the varnish film.

Dielectric Strength

29. Specimens which have been allowed to cool at least 30 min. may be tested for dielectric strength any time within a period of 4 hr. after removal from the oil. Five puncturing voltages shall be taken on the specimens in accordance with Section 15, using only Method A of the Tentative Methods D 149 - 36 T.[1] The dielectric strength shall be calculated on the basis of the average thickness of the specimen determined immediately before the dielectric breakdown test.

Report

30. The report shall include the following:

(*a*) The type of oils used (preferably including the flash point determined in accordance with the Standard Method of Test for Flash and Fire Points by Means of Open Cup (A.S.T.M. Designation: D 92) of the American Society for Testing Materials).[2]

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[1] See p. 918.

[2] 1936 Book of A.S.T.M. Standards, Part II, p. 892.

(*b*) The temperature of the oils.

(*c*) Results of the physical examination of the film (Section 28).

(*d*) The percentage increase in average thickness due to oil tests.

(*e*) The average dielectric strength in volts per mil after the oil tests.

WEIGHT

Weight

31. Specimens of sufficient size to weigh not less than 5 g. (0.18 oz.) shall be accurately weighed on an analytical balance and the weight shall be reported on some commercial unit basis such as, the weight per square yard, the weight per gross yard per 1 in. in width or the weight per roll.

THREADS PER INCH

Count

32. The count or threads per inch of the varnished cloth or varnished cloth tape shall be determined separately on the warp and filling by counting a space of not less than 1 in. (2.54 cm.) in at least five different places in the sample strip (or strips). The average of the five determinations shall be the count.

Report

33. The results of the warp count and the filling count shall be reported separately as threads per inch.

NOTE 1.—The warp threads in straight-cut materials are the threads which are parallel with the length dimension, while in bias-cut materials the warp threads are parallel with the seams and jointed selvages.

NOTE 2.—Before counting black, varnished materials it will be necessary to remove the varnish film with a knife blade or other suitable instrument. Liquid varnish removers are unsuitable for this purpose as they cause a swelling of the fibers and a shrinkage of cloth with a consequent increase in threads per inch; therefore, the films must be removed mechanically.

TENTATIVE METHODS OF TESTING VARNISHES USED FOR ELECTRICAL INSULATION[1]

A.S.T.M. Designation: D 115 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1921; REVISED, 1922, 1923, 1924, 1925, 1926, 1928, 1929, 1930, 1931, 1934, 1935, 1936.[2]

Scope

1. These tests are intended for varnishes which are applied by brushing, dipping or spraying, and are primarily for the purpose of providing electrical insulation.

DENSITY

Density

2. The density of the varnish shall be measured in grams per cubic centimeter at 25 C. ± 1 C. and recorded to the nearest 0.001 g. per cu. cm. using a wide-mouthed 25-ml. pycnometer of the Hubbard-Carmick type. The volume of the pycnometer shall be obtained by weighing the pycnometer first empty and then filled with distilled water at 25 C., and dividing the difference in weight by 0.997. The density shall be determined by dividing the weight of varnish by its volume. For convenience and accuracy a curve shall be plotted for each pycnometer showing relation between weight of pycnometer plus varnish and the density.

NOTE.—The Hubbard-Carmick type of pycnometer permits the escape of air bubbles from the more viscous types of varnishes.

VISCOSITY

Apparatus

3. Viscosimeters used in this test shall be kept calibrated over the range of viscosity of the varnishes to be tested by means of oils verified as to absolute viscosity at 25 C. by the National Bureau of Standards. A calibration curve showing the relation between viscosity in absolute units and the instrument readings shall be used.

NOTE.—A description of the MacMichael viscosimeter as remodeled and improved for varnish testing together with directions for its calibration in absolute units appears in Appendix I.

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-9 on Electrical Insulating Materials.

[2] Latest revision accepted by Committee E-10 on Standards, August 26, 1936.

Test Specimens

4. The test specimen shall consist of a portion of a varnish sample sufficient for several determinations of viscosity and maintained at a temperature of 25 C. ±1 C.

NOTE.—The sample should be kept in a nearly filled, tightly sealed container until used for test in order to avoid skin formation and the escape of solvents.

Procedure

5. (*a*) A specimen shall be poured from the sample into the viscosimeter cup which shall be kept immersed in water at such a temperature that the temperature of the varnish may be quickly brought to 25 C. ±0.2 C. The test shall be made immediately to avoid evaporation or formation of skin on the surface of the varnish. Two specimens shall be tested and the mean value reported, provided the average deviation of a single observation from the mean is not greater than 2 per cent. Otherwise, the instrument and method used shall be checked, and additional tests made until average deviation from the mean does not exceed 2 per cent.

(*b*) The viscosity shall be determined at 25 C. ±0.2 C. and the results shall be stated in terms of absolute viscosity, centipoises (Note).

NOTE.—The absolute viscosity of a material or its viscosity in absolute units (c.g.s., poises) has been defined as the force in dynes required to move, at a velocity of 1 cm. per sec., one surface having an area of 1 sq. cm. past another parallel like surface 1 cm. away, overcoming the resistance to shear of the material filling the space between. One centipoise = 0.01 poise.

Report

6. The report shall include the following:

(*a*) Individual readings in centipoises and corresponding varnish temperatures to nearest 0.1 C.

(*b*) Mean value in centipoises.

(*c*) Average deviation of individual observations from the mean in centipoises and in percentage of the mean.

(*d*) Type of viscosimeter used.

FLASH POINT

Flash Point

7. The flash point shall be determined in accordance with the Standard Method of Test for Flash Point by Means of the Pensky-Martens Closed Tester (A.S.T.M. Designation: D 93) of the American Society for Testing Materials.[1]

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 897.

TIME OF DRYING

Test Specimens

8. (*a*) Specimens for this test shall be pieces of thoroughly cleaned, smooth sheet copper or brass about 4 cm. (1.57 in.) wide and 20 cm. (7.88 in.) long and about 0.127 mm. (0.005 in.) thick.

(*b*) The specimen shall be dipped once in the varnish at a room temperature of approximately 20° C. (68° F.) and withdrawn slowly and uniformly (about 38 cm. (15 in.) per minute). The consistency of the varnish shall be first so adjusted by trial that, when dry as determined in accordance with Section 10, the average thickness of the film of varnish on each side of the metal shall be between 0.022 and 0.026 mm. (0.0009 and 0.001 in.) Care shall be taken before dipping the specimens that the varnish has stood in the dipping tank for a sufficient length of time to be free from air bubbles.

Procedure

9. (*a*) Specimens of air-drying varnish shall be dried in dust-free air at a room temperature of approximately 20° C. (68° F.).

(*b*) In the case of baking varnishes, six specimens shall be dipped and allowed to drain at a room temperature of approximately 20° C. (68° F.) until the varnish is set as indicated when the impression left on the surface by pressing lightly thereon with a finger at a point approximately 2 in. from the bottom will not become obliterated by further flow of the material. They are then to be dried in dust-free air in an oven at 105 to 110° C. (221 to 230° F.). At the end of the first 30 minutes, and again at the end of each 10-minute period thereafter, one specimen shall be taken from the oven and examined. In the case of slow-drying varnishes, this 10-minute period may be lengthened at the discretion of the operator.

NOTE.—The size of oven and the amount of ventilation have a considerable effect on the drying time of varnishes. For this reason the analytical type of electrically-heated oven should be used, and if different ovens are used they should be checked with control samples in order to determine whether they will yield comparable results.

Time of Drying

10. The varnish shall be considered dry when a piece of kraft paper 38 mm. (1.49 in.) in width and 152 mm. (6 in.) in length and approximately 0.063 mm. (0.0025 in.) in thickness does not adhere to the varnish when it is pressed on the surface of the varnish for one minute by a cylindrical 1-lb. weight, 1 in. in diameter. The kraft paper shall be applied in the vicinity of the center of the speci-

men and at right angles to it. The test shall be made at a temperature of approximately 20° C. (68° F.).

Note.—Certain types of varnishes dry with what is commonly known as a "tack"; but these types are rare. However, when testing them for drying time, it will be found that the kraft paper adheres to the varnish film and offers a certain amount of resistance to removal. On continued drying, the resistance to removal reaches constancy and is not changed by further drying. Therefore, the drying time is reported as the number of hours required to first reach constancy and the varnish should be reported as drying with a "tack."

DIELECTRIC STRENGTH TEST[1]

Scope

11. (*a*) This test is intended to determine the suitability of an insulating varnish for use in certain electrical applications by taking the dielectric strength test under different conditions of temperature and after immersion in water. The test provides for the determination of dielectric strength under the following conditions:

(*1*) At room temperature (approximately 20° C.) in air.

(*2*) At 75° C. in air.

(*3*) At room temperature after immersion in water of approximately 20° C. (68° F.) for a period of 24 hours.

Note.—Dielectric strength determinations may also be made at room temperature and at 75° C. in oil. With this exception the procedure for test is the same as outlined here. If tests are made in oil this fact must be definitely reported with the results.

(*b*) Much more information about a varnish can be obtained by making the test under all three conditions than by making it under only one condition. The relation which the dielectric strength tests for a given varnish show to one another, is of quite as much significance as the values for the different tests considered separately.

Test Specimens

12. (*a*) Specimens for the dielectric strength test shall be prepared by dipping pieces of kraft paper about 20 cm. (7.88 in.) square and about 0.076 mm. (0.003 in.) in thickness into the varnish which shall be at the consistency specified in Section 8 (*b*).

Note.—The paper used shall be that which is commercially known as No. 1 sulfate **kraft**. The surface of the paper shall be smooth, free from pimples or lumps and reasonably free from hairy fibers. The paper shall also be free from conducting particles, slime spots, creases, cuts, specks or other "paper defects."

(*b*) Each specimen shall be dipped twice, as specified in Section 8 (*b*), once in each direction, in order to give a more uniform thickness of coating. The specimen shall be dried after each dip in the same vertical position in which it was dipped.

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[1] This test is relative only, but it gives more uniform results than those obtained with a copper base. See Appendix II for a procedure for determining the dielectric strength on a copper base, p. 1058.

(*c*) Specimens of air-drying varnish shall be dried in dust-free air after each dip at a room temperature of approximately 20° C. (68° F.) for a period six times that determined in accordance with Section 10.

(*d*) Specimens of baking varnish shall be drained and then baked in dust-free air at a temperature of 105 to 110° C. (221 to 230° F.) after each dip for a period three times that determined in accordance with Section 10.

(*e*) The final thickness of the specimen shall be 0.152 mm. (0.006 in.) to within ±15 per cent.

Procedure

13. (*a*) The dielectric strength of the specimen shall be determined by applying alternating potential to two circular metal disks, 5.08 cm. (2.0 in.) in diameter and with edges rounded to a radius of 0.64 cm. (0.25 in.) which are placed in contact with the two sides of the specimen directly opposite each other and under a pressure of approximately 0.5 kg. (1.1 lb.). Starting at zero, the voltage shall be increased at a rate of approximately 0.5 kv. per second. The electrodes shall be polished and cleaned after each puncture. As the temperature of the electrodes increases after a number of tests, it is advisable to change the electrodes after every twenty punctures. Ten such punctures are to be made at various points selected at random on each specimen. After testing, the thickness of the specimen shall be determined by making five measurements on a strip cut diagonally across the specimen. The measurements shall be equally spaced along the strip except in the case of a measurement being too close to a point of puncture. The average of the five measurements shall be considered as the thickness of the specimen.

(*b*) The frequency of the test potential shall be not greater than 100 cycles per second, and each part of the testing apparatus shall have a continuous rating of not less than 2 kva. (preferably larger). The wave form shall be a sine curve as defined by the American Institute of Electrical Engineers,[1] and the voltage shall be measured by methods approved by the same organization.

(*c*) The voltage may be controlled by any approved method which does not distort the wave form beyond the limits prescribed above and which does not subdivide the voltage in steps greater than 100 volts. The apparatus shall comply with the standards of the American Institute of Electrical Engineers.[1]

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[1] **Standards of the American Institute of Electrical Engineers.**

Test Conditions

14. The dielectric strength shall be determined under the following conditions:

(*a*) At room temperature (approximately 20° C.) in air.

(*b*) At 75° C. in air.

NOTE.—The tests at 75° C. shall be made in air in an analytical type of electrically-heated oven. The electrodes shall be at oven temperature before the test is started. Tests should be started 15 minutes after the specimen has been introduced into the oven and placed between the electrodes and completed before 15 minutes additional have elapsed.

(*c*) At room temperature on specimens which shall have been immersed in water at a room temperature of approximately 20° C. (68° F.) for a period of 24 hours.

NOTE 1.—In testing specimens after immersion in water, only one specimen should be removed from the water at a time. The specimen after removal from the water should be carefully dried by placing between sheets of dry blotting paper and pressing down gently with the hand over the entire surface. If necessary, the blotting procedure should be repeated until the specimen is free from surface moisture. The specimen should then be tested immediately. If specimens are allowed to remain out of water for even a short time before testing, they dry out to a greater or less extent and the test is apt to be misleading.

NOTE 2.—Dielectric strength determinations may also be made at room temperature and at 75° C. in oil. With this exception the procedure for test is the same as outlined above. If tests are made in oil this fact must be definitely reported with the results.

Report

15. In reporting the results for each of the three tests made as described in Section 14, the total voltage at puncture, the thickness of the specimen and the volts per mil of thickness shall be reported for each of the ten punctures together with the average, maximum and minimum values. In addition, the average dielectric strength in volts per mil of the test made at 75° C. and of the test made after water immersion shall be expressed as a percentage of that made at room temperature.

HEAT ENDURANCE TEST

Test Specimens

16. (*a*) Specimens shall be prepared by dipping pieces of thoroughly cleaned, smooth sheet copper or sheet brass about 20 cm. (7.88 in.) in length, 3 cm. (1.18 in.) in width and 0.127 mm. (0.005 in.) in thickness, into the varnish. The consistency of the varnish shall previously be adjusted by trial so that, when dry as determined in accordance with Section 10, the average thickness of the film of varnish on each side of the metal shall be between 0.022 and 0.026 mm. (0.0009 and 0.001 in.).

(*b*) Each specimen shall be dipped in the varnish at room temperature of approximately 20° C. (68° F.) and withdrawn slowly and uniformly (about 38 cm. (15 in.) per minute). The varnish shall be allowed to dry in the air (if an air-drying varnish) or baked in an oven at 105 to 110° C. (221 to 230° F.) (if a baking varnish) until dry as determined in accordance with Section 10. As soon as the first coat of varnish is dry, and the specimen is at room temperature, it shall be dipped again in the varnish in the reverse direction so as to give a uniform thickness of coating. The second coat of varnish shall be allowed to dry in the same manner as the first coat. When the second coat of varnish is dry, the specimen shall be measured. The thickness of varnish on each side of the metal shall be between 0.044 and 0.052 mm. (0.00173 and 0.00205 in.).

Procedure

17. (*a*) The specimens shall be placed in a uniformly-heated oven, in which the temperature is maintained at 105 to 110° C. (221 to 230° F.). A specimen shall be removed at the end of the first 24 hours and every 24 hours thereafter.

NOTE.—Because of temperature variations between different levels in the oven, the specimen should be placed in the oven with the 8-in. dimension horizontal and the 1-in. dimension vertical. All specimens should be at the same level in the oven.

(*b*) Each specimen, after heating, shall be tested at room temperature of approximately 20° C. (68° F.) by bending it through 180 deg. around a rod 0.32 cm. (0.125 in.) in diameter.

Report

18. The number of hours of baking of the specimen which first showed cracking of the varnish film shall be reported, together with the make and type number of the oven used.

NOTE 1.—This size of oven and the amount of ventilation have a considerable effect on the heat endurance of varnish films. For this reason the analytical type of electrically-heated oven should be used, and if different ovens are used they should be checked with control samples in order to determine whether they will yield comparable results.

NOTE 2.—The temperature of the oven should be held as closely as possible to the mean (107.5° C., 225.5° F.). A difference of 5° C., (9° F.) in this temperature range, when continuously maintained, has a very considerable effect (approximately 25 per cent) on the life test of a varnish.

NOTE 3.—As the "grain" of the copper influences the result of the test, the heat endurance test specimens should be prepared by cutting the copper strips parallel with the direction of rolling.

OIL PROOF TEST

Test Specimens

19. (*a*) To test for the effect of oil, the specimens shall be prepared as prescribed in Section 16 (*a*).

(*b*) The specimens shall be dipped and dried as prescribed in Section 12 (*b*), (*c*) and (*d*).

Procedure

20. The effect of oil on the varnish shall be determined by immersing the specimens in transformer oil at a temperature of 105 to 110° C. (221 to 230° F.) for 48 hours and noting the effect on the varnish as indicated, for example, by wiping with a piece of dry white cloth.

NOTE.—Incipient disintegration of the surface of the varnish may sometimes be detected by examining the oil for turbidity. If a specimen of the used oil filtered through filter paper can be distinguished from an unfiltered sample of the used oil, when the two samples in identical containers are held in front of a diffused light, the oil is turbid.

DRAINING TEST

(ALSO KNOWN AS "WORKING VISCOSITY" TEST)

Test Specimen

21. A strip of sheet copper or brass about 4 cm. (1.57 in.) wide, 35 cm. (13.78 in.) long, and 0.127 mm. (0.005 in.) thick, shall be immersed in the varnish at a room temperature of approximately 20° C. (58° F.) up to a line previously drawn across the strip 1 in. from the top. The sheet shall be withdrawn at a slow and uniform rate (about 38 cm. (15 in.) per minute), care being taken that the varnish is free from air bubbles. The specimen shall be permitted to drain thoroughly at room temperature while suspended in a vertical position. It shall then be dried or baked (according to the type of the varnish) until dry as determined in accordance with Section 10.

Measurements

22. The thickness of the specimen in mils shall be measured at points 5.1 cm. (2 in.), 17.8 cm. (7 in.) and 30.5 cm. (12 in.), respectively, from the line to which the specimen was immersed.

Report

23. The thickness of each film in mils at the three points specified in Section 22 shall be recorded. The difference between the thickness at the upper point (5.1 cm.) and that at the lower point (30.5 cm.) shall be taken as a measure of the variation in the film thickness caused by draining.

TEST FOR NON-VOLATILE MATTER BY WEIGHT

Apparatus

24. The apparatus required consists of a chemical balance, a glass thermometer having a range of 0 to 150 or 200 C. and accurate within 1 C., a constant-temperature oven of uniform temperature, a stoppered bottle and flat bottom metal drying dishes. Each metal drying dish shall have an inside diameter of approximately $2\frac{3}{4}$ in. (7 cm.) and a depth of approximately $\frac{5}{16}$ in. (8 mm.).

NOTE.—A standard single-friction tin can cover having a diameter of $2\frac{13}{16}$ in. is suitable for use as a drying dish.

Test Specimen

25. The specimen shall consist of approximately 1.5 g. (1.35 g. to 1.65 g.) of the sample of varnish taken from the shipment.

Procedure

26. (*a*) *Preparing the Specimens.*—A portion of the sample of varnish shall be placed in a stoppered bottle or weighing pipette and weighed. Approximately 1.5 g. (1.35 g. to 1.65 g.) shall be transferred from the weighed stoppered bottle to a weighed drying dish which has previously been heated for 30 min. at 135 C. and cooled in a desiccator. The stoppered bottle with the remaining contents shall be weighed again. The exact weight of the specimen transferred to the drying dish shall be determined by difference. A total of three specimens shall be prepared from the contents of the stoppered bottle.

(*b*) *Drying the Specimens.*—The specimens shall be placed in the constant temperature oven within 30 min. after preparation. The specimens shall be heated for a period of 3 hr. at the temperature designated, as follows:

Impregnating varnishes of the phenolic-resin type......	132 to 138 C.
Other types of insulating varnishes..................	105 to 110 C.

NOTE.—In a gravity type of oven which depends upon the natural circulation of air for uniformity of temperature, only one shelf must be used for supporting the specimens, and the bulb of the thermometer for indicating the temperature shall be in close proximity to the specimens.

(*c*) *Weighing the Dried Specimens.*—At the termination of the 3-hr. heating period, the specimens shall be removed to a desiccator for cooling to room temperature. Each specimen shall be weighed immediately upon removal from the desiccator.

(*d*) *Calculation.*—The ratio of the weight of the dried specimen to the weight of the specimen in the original state expressed as a percentage is the percentage of non-volatile matter by weight.

Report

27. The report shall include the following:

(*a*) The type of varnish;
(*b*) The oven temperature, and
(*c*) The percentage of non-volatile matter.

TEST FOR VOLATILE MATTER BY VOLUME

Scope

28. This test is intended to determine the volume percentage of volatile matter (solvent) in a varnish, and to afford a means of arriving at the volume composition of the varnish with respect to volatile (solvent) and non-volatile (base) constituents.

Procedure

29. (*a*) About 100 ml. of the varnish shall be distilled in accordance with the Standard Method of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (A.S.T.M. Designation: D 86) of the American Society for Testing Materials.[1] The distillation shall be "qualitative" instead of "quantitative" as given in Section 9 of the Standard Method D 86; that is, it is not necessary to record the volume of distillate recovered, or the temperature of the initial boiling point or end point.

(*b*) The distillation shall be continued until a suitable end point indicates that all the volatile matter (solvent) has been distilled off.

NOTE.—In the distillation of varnishes the end point differs with the various types and compositions. In all cases, however, the rate of distillation slows down as the end point is approached; and, when the end point is reached, acrolein (formed in the decomposition of the varnish base) is evolved and may be detected by its characteristic odor.

In addition to the evolution of acrolein, the following phenomena are suitable indicators of end point:

(1) When the end point of the solvent is considerably lower than the initial boiling point of the base, the end point of the distillation is indicated by the temperature reaching a maximum and then starting to fall consistently.

(2) When the end point of the solvent and the initial boiling point of the base are too close, or overlap, the above temperature drop does not occur. The end point of the distillation is then indicated by a sudden foaming up of the residual base in the distillation flask; or, if the distillation has been accompanied by foaming, the end point is indicated by a breaking of surface tension with a consequent cessation of foaming.

Density.

30. The density of the volatile matter (solvent) recovered by distillation shall be determined in accordance with the procedure described in Section 2.

Volatile Matter by Weight

31. The difference between 100 per cent and the percentage of non-volatile matter determined in Sections 24 to 27 shall be calculated and recorded as the percentage of volatile matter by weight.

Volatile Matter by Volume

32. The percentage of volatile matter by volume shall be calculated from the formula:

$$x = \frac{AC}{B}$$

where

x = the percentage of volatile matter by volume;
A = the density of the original varnish, as determined in Section 2;
B = the density of the volatile matter (solvent) recovered by distillation, as determined in Section 30; and
C = the percentage of volatile matter by weight, as determined in Section 31.

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 870.

Accuracy

33. With proper care and attention to detail in making this test, differences occurring between different laboratories should not exceed 2 per cent for varnishes containing solvents which have end points not over 235° C. (455° F.), and should not exceed 4 per cent when the end point of the solvent is as high as 307.2° C. (585° F.).

DIELECTRIC STRENGTH OF VARNISH IN THE LIQUID STATE

Scope

34. The purpose of the dielectric strength test of varnish in the liquid state is to insure that the varnish is free from moisture and foreign matter such as might come from unclean shipping containers.

Apparatus

35. The apparatus shall be as described in Section 14 of the Standard Methods of Testing Molded Materials Used for Electrical Insulation (A.S.T.M. Designation: D 48) of the American Society for Testing Materials.[1] The test cup for holding the sample of varnish shall be made of a material having a suitable dielectric strength. It must be insoluble in and unattacked by mineral oil and gasoline and non-absorbent so far as moisture, mineral oil and gasoline are concerned. The electrodes in the test cup between which the sample is tested shall be circular disks of polished brass or copper, 1 in. in diameter and having square edges. The electrodes shall be mounted in the test cup having their axes horizontal and coincident, with a gap of 0.1 in. between their adjacent faces, and with top of electrodes about 33 mm. (1¼ in.) below the top of the cup.

Procedure

36. (*a*) The electrodes and the test cup shall be wiped clean with dry calendered tissue paper or with a clean dry chamois skin, and thoroughly rinsed with a suitable solvent such as dry benzol or redistilled carbon tetrachloride. The electrodes and test cup shall then be rinsed with some of the varnish to be tested.

(*b*) The spacing of electrodes shall be checked with a standard round gage having a diameter of 0.100 in. and the electrodes then locked in position. Care shall be taken not to touch the electrodes with the gage or in any other manner after cleaning the electrodes and cup, so as to avoid any possible contamination.

(*c*) The temperature of the varnish when tested shall be the same as that of the room, which should be between 20 and 30° C. (68 and 86° F.).

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 1192.

(*d*) The sample of the varnish shall be shaken so that it will be thoroughly mixed before filling the test cup, the shaking shall be done gently to avoid the formation of bubbles.

(*e*) The cup shall be filled with varnish to a height of not less than 20 mm. (0.787 in.) above the top of the electrodes.

(*f*) The varnish shall be allowed to remain in the test cup until all air bubbles have disappeared.

(*g*) Voltage shall be applied and increased uniformly at the rate of approximately 3 kv. (r.m.s. value) per second until electrical breakdown occurs as indicated by a continuous discharge across the gap. (Occasional momentary discharges which do not result in a permanent arc may occur; these should be disregarded.)

(*h*) After the breakdown and before removing the varnish from the test cup, the electrode surfaces shall be rubbed thoroughly with dry calendered tissue paper wrapped around a knife blade to provide stiffness. The test cup shall then be emptied and immediately refilled with the next filling of varnish to be tested.

(*i*) Five fillings shall be tested in conformity with the above procedure and the last filling of the cup shall drain the sample container.

Variations in Results

37. Differences as great as 15 per cent may occur between different laboratories in the results of this test. This is considered satisfactory in view of the purpose of the test.

Report

38. The report shall include the following:

(*a*) The kilovolts (r.m.s. value) at each electrical breakdown;

(*b*) The average value of the 5 breakdowns in kilovolts; and

(*c*) The mean deviation from the average value expressed as a percentage of the average breakdown value.

APPENDIX I

DESCRIPTION AND USE OF REMODELED MACMICHAEL VISCOSIMETER FOR DETERMINING VISCOSITY OF INSULATING VARNISHES

APPARATUS

The viscosity of varnishes may be determined by means of the remodeled MacMichael Viscosimeter shown in Figs. 1, 2 and 3. This instrument gives the viscosity values in terms of MacMichael degrees which are converted into absolute units of viscosity (centipoise) by means of the calibration curves of the various suspending wires.

In Fig. 1 the apparatus, consisting of the following parts, is shown unassembled:

A is the indicator by means of which the zero is adjusted and readings on scale *D* are taken.

B is the insulated wire suspension, the torsion of which measures the viscosity. The wire is fastened only at the bottom of its insulating sleeve *E′*. This is suspended by hanging it on points *P′*. (Ten wires of different size to cover various ranges of viscosities are supplied.)

C is the clamp screw which clamps the hollow spindle *E* to the sleeve *E′* which holds the torsion wire *B*.

D attached to hollow spindle *E* is the dial on which are calibrated the degrees MacMichael (300 deg. to the circumference). By means of this dial and indicator *A* the degrees deflection are determined as indicated in the method described below.

E is the hollow vertical spindle inside of which is the torsion wire sleeve *E′* which contains torsion wire *B*.

F is an oil-filled dash pot which acts as a brake to deaden oscillations and bring the suspension to rest quickly when making a determination. The dash pot swings between arm guides *F′* when the machine is assembled.

G is the brass disk which is attached to the bottom of vertical spindle *E*. Torsion wire *B* and *E′* is inserted into *E* and clamped with screw *C* and the disk *G* is then suspended in the liquid whose viscosity is being measured. Rotation of the sample cup *H* rotates the liquid and the rotating liquid exerts a certain force on the disk *G* partially rotating it and thus a torsion is produced in the wire suspension *B*, the deflection of which (or degree of torsion) is read from the scale on deflecting disk *D*.

H is the container which holds the sample. A locking device fastens it securely to *I* or *J*.

I is the water bath used for securing a uniform temperature in the liquid whose viscosity is being determined, when these viscosity measurements are desired at temperatures approximating that of the room (used on varnishes and oils).

J is the heating unit which is used in place of *I* when viscosity measurements are made at high temperatures (used on compounds).

K is the contact which carries the electric current to the heating unit cup *J*. It can be swung back when using cups *H* and *I* and when therefore electric heating is not desired.

L is the counter which indicates the revolutions per minute of the turntable *M*. A trip arrangement allows this counter to be lowered or raised, thus throwing the counter in or out of operation at will.

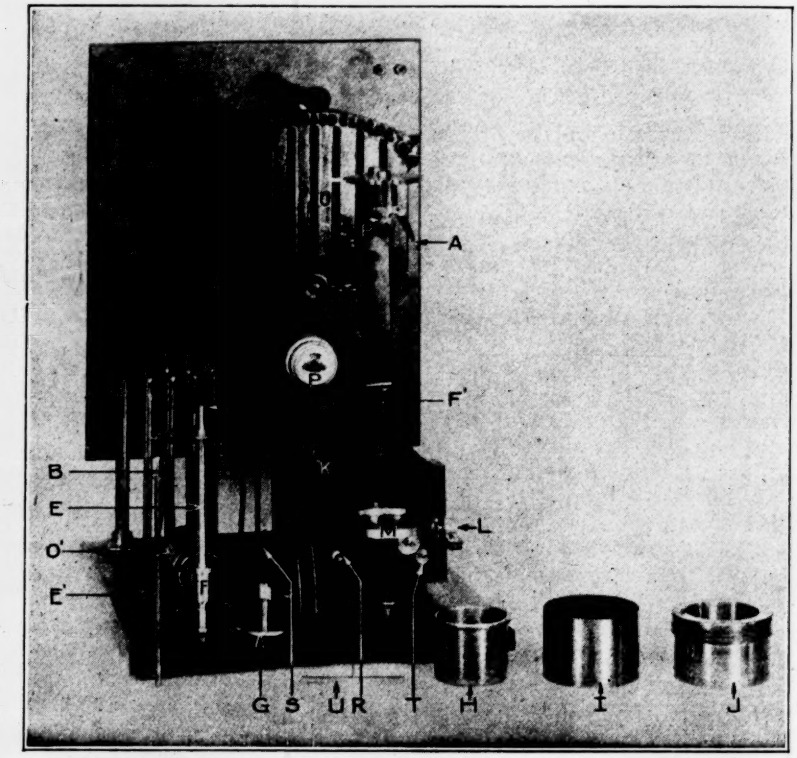

Fig. 1.—Improved MacMichael Viscosimeter Apparatus, Unassembled.

M is the rotating turntable in which *I* or *J* are set. A locking device (not shown) locks *I* or *J* securely to the turntable *M* so that when the turntable rotates the water bath or heating unit with the sample container also rotate.

N is the inclosing case under which is the motor and governor shown in Fig. 3. These operate turntable *M*.

O is a rheostat which controls the current going to the heating unit *J*.

O' is a rheostat controlling current for motor (shown only on remodeled instruments).

P is the knife switch (snap switch on new type machine) controlling the current for the heating unit *J*.

R is the push button which controls the electric current operating the motor shown in Fig. 3.

S is a leveling screw to level the instrument. Another such screw (not shown) is directly opposite to this one.

T is the governor screw that adjusts the speed of the motor by adjusting the governor shown in Fig. 3. In the remodeled apparatus the speed of rotation of turntable *M* can be decreased by moving the large gear in gear box away from the motor until pin of motor shaft is disengaged from slot of gear sleeve. The instrument is sent out with gear in low-speed position; to obtain high speeds shift gear toward motor until pin is engaged.

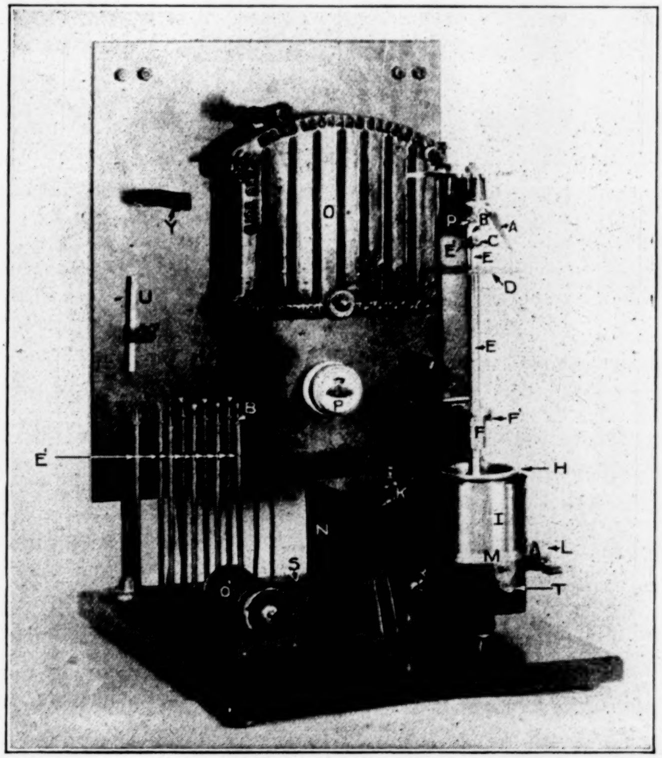

FIG. 2.—Improved MacMichael Viscosimeter Apparatus Assembled for Testing Varnish or Oil.

U is the measuring device used to measure the depth of the liquid in container *H*.

p are the projecting points on which the assembled spindle, namely, insulated torsion wire suspension *B* and *E'*, spindle and deflection dial *D*, and immersed disk *G* are suspended.

The apparatus is shown assembled in Fig. 2 for viscosity determinations on oil or varnish. Explanatory letters refer to the same parts as in Fig. 1.

In Fig. 3 are shown the internal structure and cup and heating unit assembled for testing compounds. The explanatory letters refer to the following:

V is the motor which operates the turntable *M*.

W is the governor controlling the speed of the turntable *M*.

X are the leads to connect instrument to 110-volt alternating current or direct current lighting circuit.

Y is the clamp holder for holding the spindle *E* with its dial *D*, when the machine is not in use (remodeled machines).

The heating unit *J* and the sample container, *H*, are here shown assembled as used in the viscosity determinations on compounds.

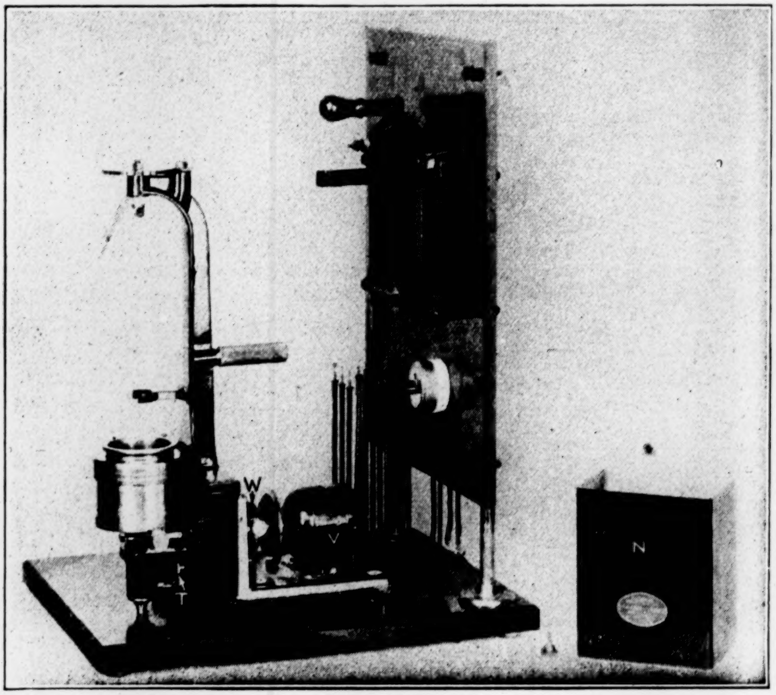

FIG. 3.—Improved MacMichael Viscosimeter Apparatus Showing Internal Structure and Cup and Heating Unit for Testing Compounds.

DIRECTIONS FOR MAKING VISCOSITY MEASUREMENTS ON VARNISH

Cups and disks must be perfectly clean. Otherwise reliable results cannot be obtained.

Dash pot *F* on the stem of the spindle should be two-thirds full of a medium grade of good machine oil (Etna Engine or Appollo) in order to dampen vibrations.

Use water bath *I* to secure and maintain the temperature of the sample in *H* when testing varnishes or oil.

Insert container *H* into water bath *I*. See that they are properly locked together, then lock bath *I* on turntable *M*.

Choose the proper torsion wire suspension for the liquid to be tested. Experience is the best guide to determine what suspension to use. Screw the disk *G* to the spindle *E*, and insert into *E* the proper insulated torsion wire suspension *E'*. Suspend these assembled parts from points *p* so the disk is suspended in the container *H*. Be sure to always suspend the wire on the points *p* with the flat side of the triangular button against the flat side of the supporting arm. The rounded surface of the triangle must face out towards the operator. Tightly fit the cover of the dash pot *F* on the arm guides F'.

See that the instrument is perfectly level. Use leveling screws *S* to adjust the instrument. The instrument is level when the suspended sleeve *E* swings exactly in the center of the hole of the cover on the dash pot.

Adjust the speed of the turntable to 60 r.p.m. This should be checked each time determinations are made. Use the governor screw *T* to adjust the speed of the motor. The gear in the gear box, referred to under *T* in the description of Fig. 1, should be in high speed position, that is, towards the motor. Use a stop watch to adjust the speed. After the speed is adjusted, lower the counter *L* so it will not operate during the following procedure.

NOTE.—The deflection is directly proportional to the speed of rotation. The 60 r.p.m. must therefore be maintained when the varnish, oil or compound is in the cup. It is, therefore, necessary to check first the revolutions per minute without the disk suspended in the sample, and again, when running a determination with the disk suspended in the sample. The motor must give the same number of revolutions per minute in each case and this value must be the same as was used for calibrating the suspension.

When the instrument is level adjust the indicator *A* to the zero mark on the dial *D*, when the spindle is suspended in the air, by moving the indicator as necessary. When the indicator has been set it must not be moved again until the test has been completed.

Fill the container *H* with the sample to be tested to a depth of 3.5 cm. A special device *U* is provided to measure this depth. Lay this device across the cup so the pointed end projects into the cup. When the surface of the liquid just touches the point, the depth of the liquid in the cup is 3.5 cm.

Raise or lower the temperature of the oil or varnishes to 21° C. by adding hot or cold water to the water bath, always stirring the sample well until a uniform temperature is secured. This is imperative. The sample may be stirred by rotating the sample cup frequently. It may also be stirred by lifting the spindle from the points *p* and stirring with the disk *G* holding the spindle by the barrel *E* and stirring by giving the disk an up-and-down movement in the sample cup. In the case of compounds, it is necessary to stir in this manner. In testing varnishes and oils, usually sufficient stirring can be obtained by rotating the cup while holding the barrel *E* to keep the disk stationary. If the spindle is removed from the points *p* it must always be suspended again with the same flat side of the supporting triangular button against the supporting arm so that the zero position is not changed.

If, when resuspending the spindle from points *p* it is noted that the zero point has moved, do not reset the indicator *A* as the change probably is due to some torsional effect produced by the sample. This may be especially noticed when testing compounds. Rotate the cup and take the reading without resetting the indicator.

When reading the thermometer have the bulb in the sample midway between the disk and the container wall and not resting on the bottom. Test the temperature at various points in the container to determine if a uniform temperature has been secured.

When a uniform temperature of 21° C. is secured, start the cup rotating by closing the switch R. Keep a hand on the switch and watch the scale on the disk D. If there is any danger that the deflection will go beyond the maximum limit for the suspension being used, open the switch immediately. Insert the next strongest wire suspension into the spindle and repeat as above indicated. When changing suspensions it is necessary to again set for zero. This may be accomplished without removing the sample, by simply removing the water bath, I, with its sample container, H, and then suspending the spindle with its new suspension on p, and leveling and adjusting as described above. It is necessary, of course, to thoroughly clean the disk, G, when doing this for if any varnish film should dry on the disk, the uneven or rough surface thus produced on the disk would cause an erroneous reading. A suspension wire should never be allowed to deflect beyond its maximum limit, for beyond this point a permanent set would be produced in the wire and a new calibration of the wire would have to be made or probably a new wire would have to be used. Table I gives a maximum and minimum limit for suspensions now in use. If the deflection is less than this minimum limit the next weakest suspension must be inserted and the test repeated. The reason for this is that at low deflections a change in slope appears on the calibration curve of the MacMichael degrees *versus* centipoises. The percentage error is magnified here and hence a reading that comes up higher in the calibration curve should be used. The maximum limit given may not be the limit to which it is permissible to deflect the wire in order to prevent its acquiring a permanent set. It, however, happens to be the limit of the calibration curve available for that suspension when the wire was calibrated.

TABLE I—MAXIMUM AND MINIMUM LIMITS FOR SUSPENSIONS.

SUSPENSION NUMBER (B. & S. Gage No.)	MINIMUM DEFLECTION, DEG. MACMICHAEL	APPROXIMATE EQUIVALENT CENTIPOISE READING	MAXIMUM DEFLECTION, DEG. MACMICHAEL	APPROXIMATE EQUIVALENT CENTIPOISE READING
30 (Weakest)	30	18	125	89
28	20	35	100	200
26	7.5	30	35	175
24	5	70	32.5	400
22	10	200	45	975
21	5	225	40	1800
20	10	750	50	4200
18	4	700	24	4000
16	2	750	11	4000
14 (Strongest)	1	1375	5	5500

Record the deflection in degrees MacMichael and read the viscosity in centipoises from the calibration curve of the suspension used.

NOTE 1.—Before any sets of suspensions are used, they must be calibrated as noted under heading "Calibration of Suspensions."

NOTE 2.—The following table gives the diameter of the wires (new American music wire gage) used in making the suspensions and the maximum limit of torsion in degrees MacMichael to which they may be subjected before they acquire a permanent set:

SUSPENSION NUMBER (B. & S. Gage No.)	DIAMETER WIRE, IN.	TORSIONAL LIMIT, DEG. MACMICHAEL
30 (Weakest)	0.0100	125
28	0.0126	118
26	0.0159	110
24	0.0201	102
22	0.0254	92
21	0.0285	81
20	0.0320	73
18	0.0403	55
16	0.0508	35
14 (Strongest)	0.0641	5

NOTE 3.—Not all of the suspension noted above are required in testing varnish Suspensions 22, 21 and 20 will be sufficient for practically all varnishes. The heavier wires 18, 16 and 14 are used for very viscous materials.

CALIBRATION OF SUSPENSIONS

For the calibration of the torsion-wire suspensions used in this apparatus to measure viscosity, samples of oils verified as to absolute viscosity at 25 C. are available from the National Bureau of Standards. Sufficient number of oils to cover the range of viscosity desired should be procured. New samples should be obtained at least once a year as it has been found that the oils undergo some change on standing over long periods. The calibration of the wires is made by testing the certified samples of oils at 25 C. ± 0.2 C., following the directions as given under heading "Directions for Making Viscosity Measurement on Varnish."

The degrees MacMichael obtained for each suspension on each sample are plotted against corresponding National Bureau of Standards absolute viscosity figures (centipoise) for those samples and a line is drawn through these points. The line should be straight except possibly at low deflections where the error is correspondingly high. Once every two months the suspension should be recalibrated.

APPENDIX II

DIELECTRIC STRENGTH TESTS ON COPPER BASE

Where it is desired to make dielectric strength tests of solid films of varnish (as distinguished from the specimens prescribed in the methods, which are a combination of varnish and paper fibers), it is recommended that copper be used as the base as formerly required in the methods. The following are the directions for preparing and testing such specimens:

1. (*a*) Specimens are prepared by dipping pieces of thoroughly cleaned, smooth sheet copper or brass about 20 cm. (7.88 in.) square and about 0.127 mm. (0.005 in.) thick into the varnish which is at the consistency prescribed in Section 5 (*b*) of the methods.

(*b*) Each specimen is dipped twice, once in each direction, in order to give a more uniform thickness of coating. The specimen is dried after each dip in the same vertical position in which it was dipped.

(*c*) Specimens of air-drying varnish are dried in free air after each dip at a room temperature of approximately 20° C. (68° F.) for a period six times as long as that determined in accordance with Section 7 of the methods.

(*d*) Specimens of baking varnish are drained and then baked after each dip for a period three times as long as that determined in accordance with Section 7 of the methods.

(*e*) The final thickness of the film of varnish on each side of the specimen is between 0.044 mm. (0.0018 in.) and 0.052 mm. (0.002 in.).

2. (*a*) The dielectric strength of the two films of varnish is determined by applying alternating potential to two circular metal disks, 5.08 cm. (2.0 in.) in diameter and with edges rounded to a radius of 0.64 cm. (0.25 in.) which are placed in contact with the two sides of the specimen directly opposite each other and under a pressure of approximately 0.5 kg. (1.1 lb.). Starting at zero, the voltage shall be increased at a rate of approximately 0.5 kv. per second. The electrodes shall be polished and cleaned after each puncture. As the temperature of the electrodes increases after a number of tests, it is advisable to change the electrodes after every twenty punctures. Ten such punctures are to be made at various points selected at random on each specimen. After testing, the thickness of the specimen shall be determined by making five measurements on a strip cut diagonally across the specimen. The measurements shall be equally spaced along the strip except in the case of a measurement being to close to a point of puncture. The average of the five measurements shall be considered as the thickness of the specimen.

NOTE.—When necessary, in order to get ten punctures, additional specimens should be tested.

(*b*) The frequency of the test potential shall be not greater than 100 cycles per second, and each part of the testing apparatus shall have a continuous rating of not less than 2 kva. (preferably larger). The wave form shall be a sine curve as defined, and the voltage shall be measured by methods approved by the American Institute of Electrical Engineers.

(*c*) The voltage may be controlled by any approved method which does not distort the wave form beyond the limits prescribed above and which does not subdivide the voltage in steps greater than 100 volts. The apparatus shall comply with the Standards of the American Institute of Electrical Engineers.

3. **The volts at puncture, the net thickness of insulation and the volts per mil of net thickness shall be reported for each of the ten tests together with the average, maximum and minimum volts per mil.**

TENTATIVE SPECIFICATIONS AND TESTS
FOR
FRICTION TAPE FOR GENERAL USE FOR ELECTRICAL PURPOSES[1]

A.S.T.M. Designation: D 69 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED AS TENTATIVE, 1920; ADOPTED IN AMENDED FORM, 1924; REVISED, 1928; REISSUED AS TENTATIVE, 1932; REVISED, 1934, 1935, 1936.

Scope

1. These specifications cover friction tape commonly used for protecting and binding in place, insulation applied to joints of electrical wires and cables, and for other electrical and mechanical purposes. The tape consists of cotton sheeting that has been impregnated with an adhesive insulating compound and cut into rolls of narrow width.

MANUFACTURE

Cotton Sheeting

2. The cotton sheeting shall be evenly and firmly woven from good cotton and as free from unsightly defects, dirt, knots, lumps and irregularities of twist as is consistent with the best manufacturing practice. The threads shall run in as straight lines as possible, without waving, so as to reduce to a minimum the raveling of the cloth when cut into tape.

Frictioning Compound

3. The frictioning compound shall be a tacky adhesive insulating compound containing practically no free sulfur or other substances which would have a deteriorating effect on copper or other metals, or on the fabric.

Impregnation of Fabric

4. The fabric shall be thoroughly impregnated and evenly covered on both sides with the frictioning compound.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-11 on Rubber Products.

These specifications are in effect a revision of, and replace the former Standard Specifications for Friction Tape for General Use for Electrical Purposes (A.S.T.M. Designation: D 69 – 28), which standard was accordingly discontinued in 1932.

Adhesiveness of Compound

5. The compound shall adhere firmly to the fabric, and shall not pull away from the fabric so as to leave bare spots when adjacent layers of tape are separated.

SAMPLING

Sampling

6. (*a*) The tape offered for inspection shall be divided into one or more lots of approximately equal numbers of rolls in accordance with the following table:

ROLLS OFFERED FOR INSPECTION	NUMBER OF LOTS
Up to 250	1
251 to 750	2
751 to 1500	3
1501 to 3000	4
3001 to 5000	5
Over 5000	5 plus 1 for each additional 1000 rolls.

The lots shall be marked for identification and one sample roll shall be taken at random from each lot for purpose of tests and marked to correspond with the lot from which it was selected. Unless otherwise specified, one specimen from each sample roll shall be tested in accordance with the specifications.

(*b*) At least 2 ft. of the outer layer of each roll selected for purpose of tests shall be removed and discarded before taking test specimens.

(*c*) The tape required for test specimens shall be unwound from the roll at a slow uniform rate without jerking.

CHEMICAL AND PHYSICAL PROPERTIES AND TESTS

Discoloration of Copper

7. The discoloration of copper test shall be made only when requested by the purchaser. Five superimposed layers of tape shall be wound on a clean, bright, smooth copper rod, approximately $\frac{1}{4}$ in. in diameter and 3 in. in length, and baked at 100 C. (212 F.) for 16 hr. in a sealed test tube. At the conclusion of the test the blue-black color, characteristic of copper sulfide, shall not appear on the rod at the edge of the tape.

Pinholes

8. The number of pinholes in a specimen of three consecutive yards of tape selected at random from any portion of the sample

roll shall not exceed six for $\frac{3}{4}$-in., eight for 1-in., twelve for $1\frac{1}{2}$-in., and sixteen for 2-in. tape. Ruptures of the insulating film at the extreme edges of the tape, due to the slight tearing action of the cutting knife, shall not be considered pinholes.

Determination of Pinholes

9. The number of pinholes shall be determined while the tape specimen is held over a slot in the top of an illuminated box. The box shall be approximately 8 in. in width by 8 in. in height and 18 in. in length, inside dimensions. The slot shall be 2 in. in width by 12 in. in length. The box shall be painted white inside and illuminated by a 25-watt lamp. The slot shall be covered with clear glass set flush with the top of the box. Means shall be provided to limit the light to the width of the tape.

Tensile Strength

10. The tensile strength of the tape specimen shall be not less than 40 lb. per inch of width. The initial distance between the jaws of the testing machine shall be 12 in. and the rate of separation of the jaws shall be 20 in. per minute.

Adhesion Test

11. (*a*) *Cold Adhesion Test.*—The adhesion between adjacent layers of the tape shall be determined as follows: A specimen 23 in. in length shall be removed from the sample roll, care being taken not to touch the surface to be tested with the hands or otherwise. One end of the specimen shall be inserted in the slot of the mandrel described below and 2 in. of the tape shall be wound on the mandrel. A weight of 10 lb. per inch of width shall then be attached to the end of the specimen and 19 in. of the tape shall be wound on the mandrel at a uniform rate of 12 in. per minute. The tape shall be allowed to remain 3 min. with the weight attached, after which a weight of 4 lb. per inch of width of tape shall be substituted for the weight of 10 lb. per inch of width, and the tape allowed to unwind. After the first 2 in. have unwound, the length that unwinds in the first 1-min. interval shall be measured and recorded. This length shall not exceed 15 in. The temperature of the room and the temperature of the tape shall be not less than 20 C. (68 F.) nor more than 22.2 C. (72 F.), except that tape meeting the adhesion test when tested at a higher room temperature shall not be rejected. The relative humidity at the temperature tested shall not exceed 80 per cent.

The mandrel used shall be $\frac{1}{4}$ in. in diameter with a slot approximately $\frac{1}{16}$ in. in width and long enough to accommodate the full width of tape, and shall be mounted in a level position in ball bearings of the Fafnir Bearing Co., Catalog No. 36, Serial No. 30, extra small, or equivalent ball bearings. The mandrel shall turn freely under a weight of $\frac{1}{4}$ oz., suspended from a cotton thread wound in a single layer on the center of the mandrel. See Fig. 1 for a suggested form of tape tester.

(*b*) *Oven Test.*—A tape specimen similar to that described in Paragraph (*a*) shall be exposed to dry air at a temperature of not less than 99 C. (210.2 F.) nor more than 101 C. (213.8 F.) for a period of 16 hr. The specimen shall be supported in the oven by means of clips or other suitable devices attached to the ends in such a way that the adhesion test portion, 19 in. in length, hangs free and not in contact with oven parts or other tape specimens. After a rest period at room temperature of not less than 1 nor more than 12 hr., during which the aged specimen shall be protected from contact with foreign material, the specimen shall withstand the test prescribed in Paragraph (*a*), except that the weight applied to unwind the tape shall be 3 lb. per inch of width in place of 4 lb. per inch of width.

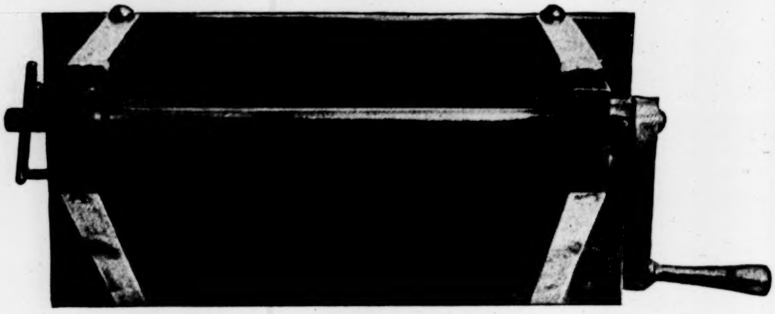

FIG. 1.—Tester for Adhesion Test of Friction Tape.

Tackiness

12. (*a*) The tape shall show tackiness, that is, ability to stick to itself after light contact has been made, in the following combinations: (*1*) front to front, (*2*) back to back, and (*3*) back to front. Two 8-in. specimens shall be cut from each sample roll, care being taken not to touch the surface to be tested with the hands or otherwise. One specimen shall be placed lightly on a clean horizontal surface, then the second placed evenly upon the first. No weight or pressure other than the weight of the specimen shall be applied to the tapes. The two specimens shall be picked up from one end and then stripped slowly from each other starting at the same end. Tackiness in at least two of the combinations (*1*), (*2*) and (*3*) specified shall be such that the point of separation remains approximately in the same horizontal plane as the hands that pull the tape apart. In the back to back combination the specimens shall show some indication

of tackiness by the point of separation traveling along the tapes as the hands pull the tape apart.

(*b*) Each combination specified in Paragraph (*a*) shall be tested three times and if more than one test fails to comply with Paragraph (*a*), the tape is non-conforming to the combination in question. Otherwise, it conforms to the combination.

(*c*) New, clean specimens shall be taken for all tackiness tests. The temperature of the room and the temperature of the tape shall be not less than 20 C. (68 F.) nor more than 22.2 C. (72 F.), except that tape meeting the tackiness test when tested at a higher room temperature shall not be rejected. The relative humidity at the test temperature shall not exceed 80 per cent.

Dielectric Strength

13. Each roll selected for purpose of tests shall be tested for dielectric strength. The breakdown voltage shall be not less than 1000 v.

Dielectric Strength Test

14. The dielectric strength shall be determined by placing a specimen approximately 6 in. in length between two flat electrodes $\frac{1}{4}$ in. in width by $4\frac{1}{4}$ in. in length. The edges shall be square and the ends rounded to $\frac{1}{8}$-in. radius cylinders whose axes are parallel to the contact faces of the electrode thus giving an area of contact with the surfaces of the tape of exactly $\frac{1}{4}$ in. in width by 4 in. in length. Under an electrode pressure of 1 lb. per sq. in., a 60-cycle alternating voltage of practically sine wave form shall be applied at a value not exceeding 100 v. and raised at a rate of 100 v. per second until puncture occurs. In order to prevent flashover, increased width may be secured by attaching to each side of the test specimen an added piece of tape, making a $\frac{1}{8}$-in. lap seam carefully rolled down.

Parallelism Test

15. Each sample roll shall be tested for parallelism of the warp threads with the longitudinal axis, as follows: A piece of tape 16 in. in length shall be cut from the sample roll and then torn lengthwise, assisting the tearing by first slitting one end for about $\frac{1}{2}$ in. with a knife. A 2-in. length shall then be cut from each end of one of the torn halves and the ends of the remaining 12-in. length folded together and compared. The difference between the compared widths shall not exceed $\frac{1}{8}$ in.

DIMENSIONS AND PERMISSIBLE VARIATIONS

Dimensions

16. (*a*) The tape shall have a nominal thickness of 0.015 in. and shall be made in the following widths: $\frac{3}{4}$ in., 1 in., $1\frac{1}{2}$ in., and 2 in. Each roll shall contain not less than $82\frac{1}{2}$ ft. and not more than 85 ft. of tape.

Permissible Variations

(*b*) The thickness shall not vary from that specified by more than ±0.002 in., nor the width by more than ±$\frac{1}{32}$ in.

Measurement of Thickness and Width

17. The thickness of the tape shall be determined by means of a micrometer graduated to 0.001 in. and having a presser foot 0.25 in. ± 0.01 in. in diameter, exerting a total force of 9 oz. ± 0.1 oz. The load shall be applied by means of a weight. Five thickness and five width measurements shall be made at random in a length of not less than 3 ft. on each sample roll and the maximum, minimum and average of these five measurements shall be reported.

PACKING AND MARKING

Packing

18. Each roll shall be wrapped in paraffin paper or its equivalent or metal foil and, unless otherwise specified, enclosed in a suitable box. The wrapping shall be secure and shall thoroughly protect the contents.

Marking

19. Each box shall be marked with the name of the manufacturer or trade mark, together with the nominal width and length of the tape.

INSPECTION AND REJECTION

Time of Inspection

20. The tape shall be inspected and tested either at the place of manufacture before shipment or at the place of delivery within 4 weeks from date of delivery.

Storage and Guarantees

21. The tape shall be stored in the original boxes and preferably in a cool, dark location. Tape shall not be stored in close proximity to steam pipes, radiators or other sources of heat. The manufacturer shall guarantee to replace tape which at any time within 8 months after acceptance of the tape, if properly stored, will not meet the cold adhesion test specified in Section 11 (*a*), except that a weight of 3 lb. per inch of width of tape shall be substituted for the 4 lb. per inch, during unwinding.

Retests and Rejection

22. (*a*) The purchaser reserves the right to reject any part of the shipment that does not comply with Sections 18 and 19.

(*b*) If the tape fails in any one test of those prescribed in these specifications, two additional rolls shall be selected and subjected to that test. If either of these two additional rolls fails, the lot represented by the test rolls shall be rejected.

(*c*) The manufacturer shall replace the rejected tape and shall pay freight charges for the return of such material.

TENTATIVE SPECIFICATIONS
FOR
INSULATED WIRE AND CABLE: CLASS AO, 30 PER CENT HEVEA RUBBER COMPOUND[1]

A.S.T.M. Designation: D 27 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1916; REVISED, 1921, 1928, 1931, 1933, 1934, 1935, 1936.[2]

Scope

1. These specifications cover the conductors, insulation, cable tape, cotton braid and lead sheaths of Class AO rubber insulated wire and cable. The design and factor of safety depend upon the service conditions and shall be at the option of the purchaser.

(*A*) CONDUCTOR

MANUFACTURE

Material

2. The conductor shall be of soft annealed copper, properly tinned, and have the properties and characteristics herein required.

Strand

3. Each individual wire of a stranded conductor shall be considered separately and shall be designated as a strand.

Shape

4. Each solid conductor and each strand shall be round and reasonably free from imperfections.

Stranding

5. The stranding shall conform to the requirements of Table I and shall be either standard concentric or flexible as specified in the order.

Density

6. For the purpose of calculating weights, cross-sections, etc., in conductivity determinations, the density of copper shall be taken as 8.89 g. per cu. cm. (See Appendix.)

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-11 on Rubber Products.

[2] Latest revision accepted by Committee E-10 on Standards, August 26, 1936.

PERMISSIBLE VARIATIONS IN DIMENSIONS

Diameter and Area

7. (*a*) *Permissible Variation.*—When the diameter of solid conductors and strands is specified, the permissible variation from the specified value shall not exceed 1 per cent under, or 3 per cent over for wire 0.010 in. in diameter or larger, and 0.1 mil under or 0.3 mil over for wire less than 0.010 in. in diameter.

When the area of cross-section of stranded conductors is specified, the permissible variation shall not exceed 1 per cent under the specified value.

(*b*) *Method of Gaging Diameter.*—When wire is submitted in coils, each coil shall be gaged in three places, one near each end and one approximately at the middle. When wire is submitted on spools or reels, approximately 12 ft. of the wire shall be reeled off and the wire then gaged in six places between the second foot and the twelfth foot from the end.

TABLE I.—STRANDING OF INSULATED CONDUCTORS.

(*1*) For intermediate sizes use stranding for next larger size.

(*2*) In assembly column, "37 by 19 rope lay," signifies 37 strands of 19 wires assembled like a rope.

(*3*) Flexible stranded Nos. 16 and 18 A. w. g. shall consist of No. 30 A. w. g. wires bunched and bound with a soft cotton wind or other material.

(*4*) Conductors of No. 0000 and smaller are often made solid and this table of stranding should not be interpreted as excluding such practice.

Size of Conductors	Standard Concentric Stranding,[a] Number of Wires	Flexible Stranding	
		Number of Wires	Assembly
2 000 000 cir. mils	127	703	37 by 19 rope lay
1 500 000 cir. mils	91	703	37 by 19 rope lay
1 000 000 cir. mils	61	427	61 by 7 rope lay
500 000 cir. mils	37	427	61 by 7 rope lay
300 000 cir. mils	37	259	37 by 7 rope lay
0 000 A. w. g	19	133	19 by 7 rope lay
1 A. w. g	19	133	19 by 7 rope lay
2 A. w. g	7	133	19 by 7 rope lay
4 A. w. g	7	49	7 by 7 rope lay
8 A. w. g	7	49	7 by 7 rope lay
10 A. w. g	7	37	Concentric
16 A. w. g	7	26	Bunched
18 A. w. g	7	16	Bunched

[a] The standard concentric stranding in this table agrees with Table XII of *Circular No. 31*, "Copper Wire and Cables," U. S. Bureau of Standards; and also Table II of Standard No. 30 "Wires and Cables" of the American Institute of Electrical Engineers.

(*c*) *Calculation of Area.*—The area of cross-section of wire shall be calculated from the average of the measurements of the diameter made in accordance with Paragraph (*b*). The area of cross-section of cable shall be considered to be the sum of the cross-sectional areas of its component wires, when laid out straight and measured perpendicular to their axes.

(*d*) *Rejection.*—A coil or reel shall be rejected if the average diameter obtained from the measurements made in accordance with

Paragraph (*b*), or the area calculated in accordance with Paragraph (*c*), is not within the limits specified in Paragraph (*a*).

A coil or reel shall be rejected if any individual measurement of diameter or of area of cross-section is not within twice the limits of Paragraph (*a*).

PHYSICAL PROPERTIES AND TESTS

Tensile Properties

8. (*a*) Each solid conductor and each strand previous to stranding shall be so drawn and annealed that after tinning it shall conform to the values in Table II.

After stranding, the tensile strength of each strand shall not exceed that specified in Table II by more than 5 per cent and the minimum elongation in 10 in. shall not be less than that specified in Table II by more than 5 per cent.

(*b*) For nominal diameters between listed sizes the requirements shall be those of the next larger sizes indicated in Table II.

Tension Tests

9. (*a*) *Method of Test.*—Tension tests shall be made on fair samples and the elongation shall be determined as the permanent increase in length, due to the breaking of the wire in tension, measured between bench marks originally 10 in. apart. The specimen shall break between the bench marks and not closer than 1 in. to either mark.

TABLE II.—TENSILE REQUIREMENTS OF CONDUCTORS.

Size of Conductor		Maximum Tensile Strength, lb. per sq. in.	Minimum Elongation in 10 in., per cent
Diameter, in.	A.w.g. Number		
0.460 to 0.290	0000 to 1	36 000	30
0.289 to 0.103	2 to 10	37 000	25
0.102 to 0.021	12 to 24	38 500	20
0.020 to 0.012	25 to 28	39 000	15
0.011 to 0.003	29 to 40	40 000	10

(*b*) *Number of Tests.*—Samples shall be taken in accordance with Section 25.

(*c*) *Retests and Rejections.*—If upon testing a sample from a coil, reel or spool of wire, the results are found to be above the stated value for tensile strength or below the stated value for elongation, tests upon two additional samples will be made and the average of the three tests shall determine acceptance or rejection.

Conductivity

10. The conductivity of the conductors after tinning shall be not less than that specified in Table III.

TABLE III.—CONDUCTIVITY REQUIREMENTS.

DIAMETER, IN.	A.W.G. NUMBER	CONDUCTIVITY, PER CENT
0.460 to 0.290	0000 to 1	97.65
0.289 to 0.103	2 to 10	97.15
0.102 to 0.021	12 to 24	96.15
0.020 to 0.012	25 to 28	94.15
0.011 to 0.003	29 to 40	93.15

NOTE.—The above values for conductivity conform to the International Annealed Copper Standard. (See Appendix I.)

Tinning Test

11. (*a*) The continuity of the tin coating of each sample before stranding or insulating shall be determined by the sodium polysulfide test which shall be made in accordance with the requirements of Sections 4 to 10, inclusive, of the Standard Specifications for Tinned Soft or Annealed Copper Wire for Rubber Insulation (A.S.T.M. Designation: B 33) of the American Society for Testing Materials.[1]

(*b*) *Number of Tests.*—Samples shall be taken in accordance with Section 25.

(*c*) *Retests and Rejections.*—If the specimens tested in accordance with Paragraph (*a*) shows any signs of blackening, two more specimens shall be tested. If one of these two additional specimens shows any blackening, that coil or reel shall be rejected. If both specimens are free from any signs of blackening, the coil or reel shall be accepted. If more than 10 per cent of the samples in the entire order fail, all of the wire shall be rejected. If 10 per cent or less of the samples in the entire lot fail, each coil, reel or length may be tested and accepted or rejected upon the results of the individual tests.

(*B*) INSULATION

Workmanship

12. (*a*) Wires and cables ordered under these specifications shall be insulated with Class AO rubber compound. Where Class A rubber compound is desired, the order shall be placed under the Tentative Specifications for Insulated Wire and Cable: Class A, 30 per cent Hevea Rubber Compound (A.S.T.M. Designation: D 393 - 34 T),[2] and where performance rubber compound is desired, under the Tentative Specifications for Insulated Wire and Cable: Performance Rubber Compound (A.S.T.M. Designation: D 353 - 36 T)[3] of the American Society for Testing Materials.

(*b*) The insulation shall consist of a properly vulcanized rubber compound which shall be homogeneous in character, tough, elastic and applied concentrically about the conductor and shall fit tightly thereto. Where the insulation is applied in more than one layer, adjacent layers shall be vulcanized into a homogeneous mass.

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[1] 1936 Book of A.S.T.M. Standards, Part I, p. 669.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, p. 1126 (1934); also 1936 Book of A.S.T.M. Tentative Standards, p. 1099.

[3] See p. 1092.

(*c*) *Shielding.*—Braided cables not supported on insulators when operating at 6001 v. and over with the neutral grounded, or 3501 v. and over with the neutral ungrounded shall be shielded or suitably protected against corona. For special installations, such as braided cables connected to an overhead line, shielding may be provided at voltages lower than those given herein.

All lead-covered multiple-conductor cables operating at 6001 v. and over with the neutral ungrounded shall be shielded or suitably protected against corona.

The shielding shall consist of a thin tinned copper tape or braid of fine tinned copper wires.

(*d*) The insulation of braided wires up to No. 7 A.w.g., inclusive, shall be covered with a single cotton braid. In multiple conductor cables the individual conductors shall not be braid-covered unless so specified. On larger sizes the fibrous covering shall consist of a cable tape and a cotton braid or two cotton braids. The cable tape shall conform to the requirements specified in Sections 53 to 56, inclusive. The cotton braid shall be applied in accordance with Sections 57 to 61, inclusive, and shall be finished in accordance with Sections 62 to 67.

(*e*) Where repairs or joints are made in the insulation, the work shall be done in such manner that the repaired part of the joint, and all parts affected in the process, shall be as strong and durable electrically and mechanically as the remainder of the insulation and shall not exceed the limitations on the thickness specified in Section 17.

MANUFACTURE

Composition

13. (*a*) Class AO rubber compound shall contain exclusively not less than 30 per cent nor more than 33 per cent of the best quality Hevea rubber which has not previously been used in a rubber compound, solid waxy hydrocarbons, suitable mineral matter, antioxidants, organic accelerators, and sufficient sulfur to properly vulcanize the compound.

(*b*) The mineral matter shall be dry.

(*c*) The waxy hydrocarbons used shall be solid at 54° C. and shall be free from saponifiable matter.

(*d*) Contamination of the compound, such as by the use of impregnated tapes, will not excuse the manufacturer from conforming to these specifications.

CHEMICAL PROPERTIES

Quantitative Requirements

14. The insulation after vulcanization shall conform on analysis to the following requirements expressed as percentages by weight of the whole sample:

	MAXIMUM	MINIMUM
Rubber, per cent	33	30
Waxy hydrocarbons, per cent	4	..
Free sulfur, per cent	0.7	..

	30 PER CENT RUBBER[a]	33 PER CENT RUBBER[a]
Saponifiable acetone extract, max., per cent	2.00	2.20
Unsaponifiable resins, max., per cent	1.00	1.10
Chloroform extract, max., per cent	0.90	1.00
Alcoholic potash extract, max., per cent	0.55	0.60
Total sulfur, max., per cent	2.10	2.30

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[a] For percentages between 30 and 33, the limits shall be in proportion to the percentage of rubber found.

Qualitative Requirements

15. (*a*) The acetone solution shall not fluoresce.

(*b*) The hydrocarbons shall be solid, waxy and not darker than a light brown.

(*c*) The chloroform extract (60 ml.) shall not be darker than a straw color.

PHYSICAL PROPERTIES

Physical Properties

16. The insulation shall conform to the following requirements as to physical properties:

Tensile strength, min., lb. per sq. in.		1200
Tensile stress at 200 per cent elongation, min., lb. per sq. in.		300
Elongation at rupture, min., per cent		400
Set in 2-in. gage length, max., in.		⅜
Depreciation in tensile strength and elongation after oxygen bomb test, max., per cent		25
Depreciation in tensile strength and elongation after Geer oven test, max., per cent		15
Specific gravity, min.	30 per cent rubber	1.75[a]
	33 per cent rubber	1.67[a]

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[a] For percentages between 30 and 33, the specific gravity limits shall be in proportion to the percentage of rubber found.

THICKNESS

Thickness

17. (*a*) The average thickness of the insulation shall be not less than that given in Table IV. The minimum thickness shall be not

TABLE IV.—THICKNESS OF INSULATION AND ALTERNATING TEST VOLTAGE.

NOTE 1.—Rated circuit voltage of alternating-current circuits is the phase-to-phase voltage.

NOTE 2.—For an intermediate size of wire or an intermediate rated circuit voltage, the thickness and test voltage shall be that for the next larger size or higher rated circuit voltage.

NOTE 3.—For non-leaded submarine cables, $\frac{1}{32}$ in. should be added to the specified respective walls of insulation in this table for all sizes and voltages.

NOTE 4.—Rated circuit voltages from 0 to 5000 v. in this table apply to wire for use on grounded and ungrounded circuits.

NOTE 5.—Above 5000 v. alternating-current, special high-voltage rubber compounds are preferred according to manufacturer's recommendations.

Rated Circuit Voltage	Size of Conductor, A. w. g. Numbers or Circular Mils	Insulation Thickness on each Conductor, sixty-fourths of an inch	Test Voltage
0 to 300	No. 18 to No. 16	2	1 000
0 to 600	No. 14 to No. 9	3	3 000
	No. 8 to No. 2	4	3 500
	No. 1 to No. 0000	5	4 000
	225 000 to 500 000 cir. mils	6	5 000
	525 000 to 1 000 000 cir. mils	7	6 000
	Over 1 000 000 cir. mils	8	7 000
601 to 1000	No. 14 to No. 8	4	5 000
	No. 7 to No. 2	5	6 000
	No. 1 to No. 0000	6	7 500
	225 000 to 500 000 cir. mils	7	9 000
	525 000 to 1 000 000 cir. mils	8	10 000
	Over 1 000 000 cir. mils	9	11 000
1001 to 2000	No. 14 to No. 8	5	6 000
	No. 7 to No. 2	6	7 500
	No. 1 to No. 0000	7	9 000
	225 000 to 500 000 cir. mils	8	10 000
	525 000 to 1 000 000 cir. mils	9	11 000
	Over 1 000 000 cir. mils	9	11 000
2001 to 3000	No. 14 to No. 8	7	9 000
	No. 7 to No. 2	8	10 000
	No. 1 to No. 0000	8	10 000
	225 000 to 500 000 cir. mils	9	11 000
	525 000 to 1 000 000 cir. mils	9	11 000
	Over 1 000 000 cir. mils	10	12 500
3001 to 4000	No. 14 to No. 8	9	11 000
	No. 7 to No. 2	9	11 000
	No. 1 to No. 0000	9	11 000
	225 000 to 500 000 cir. mils	10	12 500
	525 000 to 1 000 000 cir. mils	10	12 500
	Over 1 000 000 cir. mils	11	13 500
4001 to 5000	No. 14 to No. 8	10	12 500
	No. 7 to No. 2	10	12 500
	No. 1 to No. 0000	10	12 500
	225 000 to 500 000 cir. mils	11	13 500
	525 000 to 1 000 000 cir. mils	11	13 500
	Over 1 000 000 cir. mils	12	15 000
5001 to 6000 (grounded)	No. 14 to No. 0000	10	12 500
	225 000 to 1 000 000 cir. mils	11	13 500
	Over 1 000 000 cir. mils	12	15 000
5001 to 6000 (ungrounded)	No. 14 to No. 0000	12	15 000
	225 000 to 1 000 000 cir. mils	12	15 000
	Over 1 000 000 cir. mils	13	16 500
6001 to 7000 (grounded)	No. 8 to No. 0000	11	13 500
	225 000 to 1 000 000 cir. mils	11	13 500
	Over 1 000 000 cir. mils	12	15 000
6001 to 7000 (ungrounded)	No. 8 to No. 0000	14	17 500
	225 000 to 1 000 000 cir. mils	14	17 500
	Over 1 000 000 cir. mils	15	19 000
7001 to 8000 (grounded)	No. 8 to No. 0000	12	15 000
	225 000 to 1 000 000 cir. mils	12	15 000
	Over 1 000 000 cir. mils	13	16 500
7001 to 8000 (ungrounded)	No. 8 to No. 0000	16	20 000
	225 000 to 1 000 000 cir. mils	16	20 000
	Over 1 000 000 cir. mils	17	21 000

less than 95 per cent of the thickness required by Table IV for insulations less than $\frac{4}{64}$ in. in thickness and not less than 90 per cent of the specified thickness for insulations of $\frac{4}{64}$ in. and greater.

(*b*) The thicknesses in Table IV apply to single conductor cable and the individual conductors of multiple conductor cables, leaded or braided, except special applications such as aerial, non-leaded submarine, and vertical riser cable.

NOTE.—In Appendix II will be found an interpretation of the insulation thicknesses given in Table IV.

TABLE V.—INSULATION RESISTANCE, MEGOHMS-1000 FT. AT 60° F. (15.5° C.).

NOTE 1.—This table is based on a constant, $K = 21\,120$ in the following formula:

$R = K \log_{10} \frac{D}{d}$; where R = resistance in megohms-1000 ft., K = constant.

D = diameter over insulation, on each conductor, and d = diameter over conductor.

NOTE 2.—For an intermediate size, the insulation resistance shall be that of the next larger size.

Size of Conductor, A. w. g. Numbers or Circular Mils	Solid or Stranded	Diameter in Inches	Insulation Thickness in Sixty-fourths of an Inch									
			2	3	4	5	6	7	8	9	10	12
No. 18	Solid	0.040	8600	11 100	....	....	....	....	....	....	....	....
No. 16	Solid	0.051	7300	9 500	....	....	....	....	....	....	....	....
No. 14	Solid	0.064	....	8 300	9900	11 300	12 550	13 650	14 600	15 450	16 250	17 650
No. 12	Solid	0.081	....	7 050	8550	9 850	11 000	12 000	12 900	13 750	14 500	15 850
No. 10	Solid	0.102	....	6 000	7350	8 500	9 600	10 500	11 350	12 100	12 850	14 150
No. 8	Solid	0.128	....	....	6200	7 300	8 300	9 150	9 950	10 650	11 350	12 550
No. 6	Stranded	0.184	....	....	4750	5 600	6 400	7 200	7 900	8 500	9 100	10 200
No. 4	Stranded	0.232	....	....	3900	4 700	5 450	6 100	6 700	7 250	7 800	8 850
No. 2	Stranded	0.292	....	....	3250	3 900	4 550	5 150	5 650	6 150	6 650	7 600
No. 1	Stranded	0.332	....	....	....	3 550	4 100	4 650	5 150	5 600	6 100	6 950
No. 0	Stranded	0.373	....	....	....	3 200	3 750	4 200	4 700	5 150	5 550	6 350
No. 00	Stranded	0.418	....	....	....	2 900	3 400	3 850	4 300	4 700	5 100	5 850
No. 000	Stranded	0.470	....	....	....	2 600	3 100	3 500	3 900	4 250	4 650	5 400
No. 0000	Stranded	0.528	....	....	....	2 400	2 800	3 150	3 550	3 900	4 200	4 900
250 000 cir. mils	Stranded	0.575	....	....	....	....	2 600	2 950	3 300	3 650	4 000	4 600
350 000 cir. mils	Stranded	0.681	....	....	....	....	2 250	2 550	2 850	3 150	3 450	4 000
500 000 cir. mils	Stranded	0.814	....	....	....	....	1 900	2 200	2 450	2 700	2 950	3 450
750 000 cir. mils	Stranded	0.998	....	....	....	....	....	1 800	2 050	2 250	2 500	2 900
1 000 000 cir. mils	Stranded	1.152	....	....	....	....	....	1 600	1 800	2 000	2 200	2 600
1 250 000 cir. mils	Stranded	1.289	....	....	....	....	....	....	1 600	1 800	2 000	2 350
1 500 000 cir. mils	Stranded	1.412	....	....	....	....	....	....	1 500	1 650	1 850	2 150
1 750 000 cir. mils	Stranded	1.526	....	....	....	....	....	....	1 400	1 550	1 700	2 000
2 000 000 cir. mils	Stranded	1.631	....	....	....	....	....	....	1 300	1 500	1 600	1 900

ELECTRICAL PROPERTIES

High Voltage Test

18. Each coil, reel, or length of wire or cable, after vulcanization shall successfully withstand the application of an alternating voltage of not less than that prescribed in Table IV for a period of 5 minutes. (See Sections 47 and 48.)

Insulation Resistance

19. Each coil, reel, or length of wire or cable after being subjected to the high voltage test specified in Section 18 shall have an insulation resistance not less than that given in Table V.

Moisture Absorption

20. (*a*) The increase in the specific inductive capacity of the

insulation shall be used as an indication of the amount of moisture absorbed.

(*b*) The specific inductive capacity after 24-hr. immersion in water shall not exceed six. The increase between the ends of the first and the fourteenth days shall not exceed 20 per cent and that between the ends of the seventh and fourteenth days, 5 per cent.

(*c*) The specific inductive capacity shall be determined at either 1000 or 60 cycles. Where measured at 1000 cycles, the voltage impressed upon the conductor shall not exceed 10 volts. Where measured at 60 cycles, the voltage impressed upon the conductor shall be equivalent to a stress of between 30 to 40 volts per mil of insulation.

(*d*) The measurements shall be made as described in Section 52.

METHODS OF TESTING

CHEMICAL ANALYSIS

Sampling

21. Samples of the vulcanized rubber compound for chemical analysis shall be taken after the successful completion of the physical and electrical tests, and before applying impregnating compounds which may contaminate the rubber. The samples shall be taken at the option of the purchaser. The purchaser shall assure himself that all samples are free from contamination and change due to torch heating. Wherever practicable, samples shall be taken at a distance of at least 3 ft. from the end of the wire.

Procedure

22. The insulation shall be analyzed in accordance with the Complete Procedure as described in the Standard Methods of Chemical Analysis of Rubber Products (A.S.T.M. Designation: D 297) of the American Society for Testing Materials.[1]

Rejection and Retests

23. The purchaser may make a chemical analysis on any one of the samples selected as described in Section 21 to determine if the compound conforms to the requirements of Sections 14 and 15. Failure of any sample selected to conform to the requirements shall be sufficient cause for rejecting the wire which that sample represents, except in the case of failure to conform to the requirements for either or both free sulfur and chloroform extract. In case of such failure, the coil from which the sample was taken shall be rejected and two additional samples shall be selected from the remainder of the order. The remainder of the order shall be accepted if both samples so selected conform to the requirements for free sulfur or chloroform extract. The entire order shall be rejected if either sample fails.

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 1249.

SPECIFIC GRAVITY

Specific Gravity

24. The specific gravity shall be determined in accordance with Section 14 of the Standard Methods of Chemical Analysis of Rubber Products (A.S.T.M. Designation: D 297) of the American Society for Testing Materials.[1]

TENSILE STRENGTH, SET AND ELONGATION AT RUPTURE

Sampling for Physical Tests

25. (*a*) Wire up to and including 250,000 cir. mils in size shall be sampled in accordance with the following requirements:

QUANTITY OF WIRE	NUMBER OF SAMPLES
2000 ft. and under	none
2001 to 10,000 ft.	1 for each 2000 ft. or fraction thereof
10,001 to 100,000 ft.	5 plus 1 for each 10,000 ft. additional over 10,000 ft.
100,001 to 500,000 ft.	14 plus 1 for each 25,000 ft. over 100,000 ft.

(*b*) For wire larger than 250,000 cir. mils, one sample shall be selected from quantities between 1000 and 2000 ft. and for larger quantities double those specified in Paragraph (*a*).

Test Specimen

26. (*a*) *Size.*—The test specimen may be the entire section of the insulation in the case of small wires, or, in the case of a large wire or cable, either a segment of a section cut with a sharp knife held tangentially to the conductor or a shaped specimen cut out with a standard die. The test specimen shall be as free as possible from surface incisions and imperfections. There shall be no limit to the cross-section of the test specimen, except as restricted by the capacity of the testing machine.

NOTE.—The removal of the rubber insulation can be greatly accelerated and in most cases a test specimen which is an entire section can be obtained free from surface incisions and imperfections by means of metallic mercury. The mercury should be introduced at one end of the sample between the insulation and the tinned surface of the conductor, and the sample inclined on a support with the end to which the mercury is applied at the top. The separation of the rubber insulation results from the amalgamation of the tin of the conductor with the mercury. The amalgamation is assisted by first immersing and rubbing the tinning on the exposed end of the conductor in the mercury.

(*b*) *Condition and Age.*—Specimens shall not be heated, immersed in water or subjected to any mechanical or chemical treatment not specifically prescribed in these specifications. Specimens for accelerated aging tests shall be taken from the completed wire after the application of the specified covering and shall be aged with all such covering removed. No tests shall be made within 24 hours nor later than 60 days after vulcanization unless agreed to by the manufacturer.

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 1249.

(c) *Buffing.*—In the event of any irregularities on the surface of the test specimen, it shall be made smooth and of uniform thickness within 5 per cent of the original thickness by buffing, except when large strands are used, in which case the rubber sample shall be buffed sufficiently to remove all corrugations.

Calculation of Area

27. Calculation of the area of the test specimens shall be made as follows:

(*a*) Where the total cross-section of the insulation is used, the area shall be taken as the difference between the area of the circle whose diameter is the minimum average outside diameter of the insulation and the area of the conductor. The area of a stranded conductor shall be calculated from its maximum diameter.

(*b*) Where a slice cut from the insulation by a knife held tangent to the wire is used, and the slice so cut has the cross-section of a segment of a circle, the area shall be calculated as that of the segment of a circle whose diameter is that of the insulation. The height of the segment is the wall of insulation on the side from which the slice is taken. (The values may be obtained from a table giving the areas of segments of a unit circle for the ratio of the height of the segment to the diameter of the circle.)

(*c*) Where the cross-section of the slice is not a segment of a circle, the area shall be calculated from a direct measurement of the volume or from the specific gravity and the weight of a known length of the specimen having a uniform cross-section.

(*d*) Where a portion of a sector of a circle has to be taken where the conductor is large and the insulation thin, the area shall be calculated as the thickness times the width. (This applies either to a straight test piece or one stamped out with a die, and assumes that corrugations have been removed by buffing.)

(*e*) Where a portion of a sector of a circle has to be taken where the conductor is large and the insulation thick, the area shall be calculated as the proportional part of the area of the total cross-section.

Temperature at Test

28. Physical tests shall be made at a room temperature not less than 65° F. (18.3° C.) nor more than 90° F. (32.2° C.) and the test specimen shall have been kept at the room temperature not less than 30 minutes prior to the test.

Tension Testing Machine

29. The tension testing machine shall be power-driven and preferably of the pendulum type. The machine shall be accurate within 1 per cent of the breaking load. A spring balance type of apparatus

may be used if provided with a device which will indicate the actual maximum load at which rupture takes place and if provision is made to prevent recoil of the spring.

Tensile Strength Test Procedure

30. The tensile strength test shall be made on a specimen which has not been previously stretched. The specimen shall have a length of not less than 6 in., and shall be marked with gage marks 2 in. apart and placed in the jaws of the testing machine with a maximum distance between jaws of 4 in. The specimen shall be stretched at the rate of 20 in. per minute (jaw speed) until it breaks. The test specimen shall break between the gage marks. The tensile strength shall be calculated upon the area of the original specimen.

Tensile Stress Test

31. The tensile stress test shall be made in conjunction with the tensile strength test by recording the load when the 2-in. gage length marks are 6 in. apart, that is, at 200 per cent elongation. The tensile stress shall be calculated upon the original area of the specimen.

Elongation at Rupture Test Procedure

32. The percentage of elongation at rupture shall be determined simultaneously with the tensile strength and on the same specimen.

The elongation at rupture shall be taken as the distance between gage marks at rupture less 2 in. (the original gage length of the set test specimen). The percentage of elongation at rupture is the elongation in inches divided by the original gage length (2 in.) and multiplied by 100 to express as a percentage.

Set Test Procedure

33. The set test shall be made on a separate test specimen having a length of not less than 6 in. and marked with gage marks 2 in. apart. The specimen shall be placed in the jaws of the testing machine with a maximum distance between jaws of 4 in. and shall be stretched at the rate of 20 in. per minute (jaw speed) until the gage marks are 6 in. apart. The test specimen shall then be released within 5 seconds and the distance between gage marks shall be determined 1 minute after the beginning of release. The set is the difference between this length and the original 2-in. gage length.

Retests, Physical Properties

34. Where tested in accordance with Sections 30, 31, 32 and 33, if a specimen fails to conform to any one of the requirements for tensile strength, tensile stress, set, or elongation at rupture specified in Section 16, two additional specimens shall be taken from the same sample and tested, and the average of the results shall determine whether the material conforms to the requirements.

AGING TESTS

Sampling for Aging Tests

35. For aging tests the wire shall be sampled as follows:

No samples shall be selected where the quantity is less than 2000 ft. of wire or cable.

For sizes less than 250,000 cir. mils, one sample shall be selected for each quantity ordered between 2000 ft. and 50,000 ft. of wire or cable and one additional sample for each additional 50,000 ft. thereafter.

For sizes 250,000 cir. mils and over, one sample shall be selected for each quantity ordered between 2000 ft. and 25,000 ft. of wire or cable and one additional sample for each additional 25,000 ft. thereafter.

Test Specimens

36. Nine test specimens of similar size and shape shall be prepared from each sample selected in accordance with Section 35, three for the determination of the initial or unaged properties, three for the oxygen bomb test and three for the Geer oven test. One specimen of each three shall be tested and the other two held as spares except that where only one sample is selected all three specimens shall be tested and the average of the results reported.

Aging Test Conditions

37. (*a*) In the case of wire and cable smaller than No. 6 A.w.g. with an insulation thickness less than $\frac{3}{32}$ in., the insulation shall be heated in the oxygen bomb and in the Geer oven without removing the conductor.

(*b*) In the case of wire and cable of No. 6 A.w.g. and larger or with an insulation thickness greater than $\frac{3}{32}$ in., samples approximately square in section shall be cut from the insulation with a cross-section not greater than 0.025 sq. in.

(*c*) Die-cut samples shall be buffed before being subjected to the accelerated aging test wherever the thickness of the sample is $\frac{3}{32}$ in. or greater after buffing.

(*d*) The test specimens shall have no protective covering and shall be suspended vertically in such a manner that they will not come in contact with each other or with the sides of the bomb or oven.

(*e*) Physical tests on both aged and unaged specimens shall be made at the same time. The aged specimens shall have a rest period of not less than 16 hr. nor more than 48 hr. between the completion of the aging and the determination of the physical properties.

Oxygen Bomb Test

38. The test specimens shall be heated in an atmosphere of oxygen at a pressure of 300 lb. per sq. in. at a temperature of from 157 to

159° F. for a period of 96 hours. The weight of the rubber in the bomb shall not be over 2 g. per cu. in. of bomb space. The bomb pressure shall be reduced at a uniform rate, requiring at least two minutes, when specimens are removed. The bomb temperature shall be recorded automatically on a chart.

Geer Oven Test

39. The test specimens shall be heated at a temperature of from 157 to 159° F. for a period of 96 hours in an oven having a free circulation of fresh air. The oven temperature shall be recorded automatically on a chart.

Retests, Aging

40. Should the first set of specimens selected under Section 35 fail to meet the specifications, two other sets of specimens shall be tested and if either of these sets fails, the coils, reels or lengths will be rejected.

Rejection

41. When ten or more samples are selected in any inspection lot, all coils, reels or lengths may be rejected if more than 10 per cent of the samples fail. If 10 per cent or less fail, each coil, reel or length may be tested and shall be accepted or rejected upon the results of such individual tests. Where the number of samples selected in any inspection lot is less than ten, all coils, reels or lengths shall be rejected if more than 20 per cent of the samples fail. If 20 per cent or less fail, each coil, reel or length may be tested and shall be accepted or rejected upon the result of such individual tests.

THICKNESS

Apparatus

42. The thickness measurements may be made with any type of micrometer reading to 0.001 in., suitable for measurements of this character.

Number of Measurements

43. Where the lot of wire to be inspected consists of two coils or reels or less, at least one determination of the thickness shall be made on each coil or reel. Where the lot consists of more than two coils or reels and less than 20 coils or reels, at least one determination of the thickness shall be made on each of two coils or reels taken at random. If the lot consists of 20 or more coils or reels, not less than 10 per cent of the coils or reels shall be selected at random and at least one determination of the thickness made on each coil or reel so selected.

Procedure

44. The average thickness of the insulation shall be taken as one-half the difference between the mean of the maximum and minimum diameters measured at any one point and the average diameter of the conductor measured at the same point. The minimum thickness shall be taken as the difference between a measurement made over the conductor plus the thinnest wall and the diameter of the conductor. (The first measurement is made by "slicing off" the heavier side of the insulation.)

In the case of multiple-conductor cable, the measurements shall be made on the individual wires before being cabled.

Rejection

45. If the thickness of the insulation of any coil or reel is found to be less than the specified value, that coil or reel shall be rejected and a thickness measurement on each of the remaining coils or reels shall be made.

TABLE VI.—TEMPERATURE COEFFICIENTS.

Temperature		Temperature Coefficient	Temperature		Temperature Coefficient
Deg. Fahrenheit	Deg. Centigrade		Deg. Fahrenheit	Deg. Centigrade	
46	7.8	0.69	61	16.1	1.03
47	8.3	0.71	62	16.7	1.05
48	8.9	0.73	63	17.2	1.08
49	9.4	0.75	64	17.8	1.11
50	10.0	0.77	65	18.3	1.14
51	10.6	0.79	66	18.9	1.17
52	11.1	0.81	67	19.4	1.20
53	11.7	0.83	68	20.0	1.23
54	12.2	0.85	69	20.6	1.26
55	12.8	0.88	70	21.1	1.30
56	13.3	0.90	71	21.7	1.33
57	13.9	0.92	72	22.2	1.37
58	14.4	0.94	73	22.8	1.40
59	15.0	0.97	74	23.3	1.44
60	15.6	1.00	75	23.9	1.48

ELECTRICAL TESTS

Place of Testing

46. Electrical tests of wire and cable shall be made at the place of manufacture.

High Voltage Test

47. The high voltage test shall be made with alternating potential from a transformer and generator of ample capacity and in no case less than 5 kva. The frequency of the test voltage shall be not greater than 100 cycles and shall have a wave shape approximating as closely as possible a sine curve.

Rate of Application

48. The initially-applied voltage shall be not greater than the rated voltage and the rate of increase shall be approximately uniform and not over 100 per cent in 10 seconds nor less than 100 per cent in 60 seconds.

High Voltage Testing

49. (*a*) *General.*—Where insulated conductors are subjected to a high voltage test in water they shall be immersed in a grounded water bath and tested while still immersed.

(*b*) *Single Conductor.*—Single conductors shall be tested after 12-hr. immersion and without covering except a tape or braid applied before vulcanization.

Rubber sheathed conductors shall be immersed and tested after the sheath is applied.

Where a metallic sheath is applied, the conductors shall be retested against the sheath.

(*c*) *Multiple Conductor.*—The individual conductors of multiple conductor cables shall be tested before assembling as prescribed in Paragraph (*b*).

After assembly each conductor shall be tested against the adjacent conductors. Where a metallic sheath is applied each conductor shall in addition be tested against the sheath.

Cables having a rubber or other non-metallic waterproof sheath shall be immersed for 12 hr. and the conductors tested against ground. Cables covered with cable tape and braid or double braid with a weather-resistant finish shall not be immersed for testing.

Application of Voltage

50. (*a*) *Single-Conductor Cables.*—Single-conductor cables shall be tested between conductor and sheath or water in which they are immersed.

(*b*) *Multiple-Conductor Cables.*—If a multiple-conductor cable is rated at the same operating voltage between conductor and sheath or water as between conductors, each conductor shall be tested against the other conductors in the cable and against the sheath or water, at the test voltage prescribed for that rated voltage. If a cable is rated at a voltage between conductors and ground different from that between conductors, the test between conductors shall be made at the test voltage prescribed for the rated voltage between conductors and the test between each conductor and sheath or water, shall be made at the test voltage prescribed for the rated voltage between conductors and sheath or water.

The several tests may be made by any arrangement of testing transformers suitable for the prescribed tests, such as one or more transformers supplied from a single-phase source or three transformers connected in star and supplied from a three-phase source.

Insulation Resistance

51. (*a*) The insulation resistance shall be measured after the high-voltage test has been made and while the wire or cable is still immersed in water. The measurement shall be made after one-minute electrification with a continuous e.m.f. of from 100 to 500 volts, the conductor being maintained negative to the water. The temperature of the water shall be within the limits given in Table VI.

Temperature Coefficient

(*b*) If the temperature at which the insulation resistance was measured differs from 60° F. (15.5° C.), the resistance shall be reduced to that at 60° F. (15.5° C.) by multiplying the measured value by the coefficient in Table VI corresponding to the temperature at which the measurement was made.

Moisture Absorption Test

52. (*a*) A 15-ft. sample with all the coverings removed shall be selected at random from the wire offered for inspection. The middle 10 ft. of the sample shall be immersed in distilled water for a period of 14 days with the 2½-ft. portion at each end kept above the water as leakage insulation. The three measurements specified in Section 20 shall be taken with the water at the same temperature. The water shall be maintained at room temperature, but not less than 70 F. (21 C.).

(*b*) The specific inductive capacity of the insulation shall be determined at commercial frequencies and shall be calculated as follows:

$$\text{Specific inductive capacity} = 13{,}600\ C \log_{10} \frac{D}{d}$$

where C = the capacity in microfarads of 10 ft. of sample;
D = the diameter over insulation; and
d = the diameter over conductor.

The moisture absorption test shall be made only when requested by the purchaser.

(*C*) CABLE TAPE

Material

53. Cable tape shall be made from cotton cloth having a weight of not less than 1 lb. per 4 yd. based on a width of 36 in. and not less than 56 by 60 picks per inch, and shall be frictioned on both sides and thoroughly filled with a rubber compound. The nominal thickness shall be 0.012 in. and not less than 0.011 in.

Application

54. The tape shall be applied helically and may be applied before vulcanization. The maximum width and minimum overlap shall conform to the values in Table VII.

Intermediate Diameters

55. For intermediate diameters the requirements shall be those of the next smaller diameter indicated in Table VII.

Number of Tests

56. Samples shall be taken at the option of the purchaser.

TABLE VII.—WIDTH AND OVERLAP OF RUBBER-FILLED CABLE TAPE.

DIAMETER OVER INSULATION, IN.	MAXIMUM WIDTH OF TAPE, IN.	MINIMUM OVERLAP, IN.
2.00	5	½
1.75	4½	½
1.50	4	½
1.25	3½	½
1.15	3¼	½
1.00	3	½
0.88	2¾	⅜
0.75	2⅜	⅜
0.62	2	⅜
0.50	1¾	⅜
0.38	1½	¼
0.31	1¼	¼
0.25	1	¼
0.19	⅞	3/16
0.16	¾	3/16

TABLE VIII.—TANGENT OF ANGLE OF BRAID.

DIAMETER UNDER BRAID, IN	VALUE OF TANGENT	CORRESPONDING BRAID ANGLE, DEG.
0 to 1.00	0.700	35
1.001 to 1.500	0.839	40
1.501 and over	1.000	45

(*D*) COTTON BRAID

Braids

57. (*a*) Two types of cotton braid are covered in these specifications, namely, standard braid and heavy braid, as follows:

Standard Braid is designed for indoor service and installation in conduits.

Heavy Braid is designed for outdoor and rough service.

(*b*) Unless otherwise specified, standard braid shall be supplied under these specifications.

Material

58. Cotton braid shall be closely woven from cotton thread having not less than two plies.

Construction

59. (*a*) The braid shall be so constructed that the tangent of the angle between the cotton thread and the side of the wire shall be not less than that specified in Table VIII.

(*b*) The thickness of standard braid shall be not less than that specified in Table IX and that of heavy braid not less than that specified in Table X.

TABLE IX.—MINIMUM THICKNESS OF STANDARD BRAID.

DIAMETER UNDER BRAID, IN.	MINIMUM THICKNESS OF BRAID, IN.	CORRESPONDING MINIMUM SIZE AND PLY OF COTTON YARN
0 to 0.200	0.0163	30/2
0.201 to 0.350	0.0175	26/2
0.351 to 0.800	0.0200	20/2
0.801 to 1.500	0.0258	12/2
1.501 to 3.000	0.0316	8/2

TABLE X.—MINIMUM THICKNESS OF HEAVY BRAID.

DIAMETER UNDER BRAID, IN.	MINIMUM THICKNESS OF BRAID, IN.	CORRESPONDING MINIMUM SIZE AND PLY OF COTTON YARN
0 to 0.200	0.020	20/2
0.201 to 0.300	0.0223	16/2
0.301 to 0.600	0.0258	12/2
0.601 to 1.000	0.0316	8/2
1.001 to 1.500	0.037	6/2
1.501 to 2.000	0.0446	4/2
2.001 to 3.000	0.0556	4/3

(*c*) The number of carriers and the number of ends per carrier used in applying the braid shall be optional providing all other limitations of Sections 58 and 59 are met. However, the picks per inch shall be not less than the value as calculated by the following formula:

$$P = \sqrt{\left[\frac{1}{tE + M}\right]^2 - \left[\frac{C}{2\pi\,(D + T)}\right]^2}$$

where P = the picks per inch;

T = the thickness of braid, in inches; $T = 2t$

t = the thickness of one end of cotton, in inches; $t = \dfrac{0.0279\,K}{\sqrt{S}}$

K = cabling factor for plied yarn; values of K are: $\begin{cases} 2 \text{ ply} = 1.60 \\ 3 \text{ ply} = 2.00 \\ 4 \text{ ply} = 2.36 \end{cases}$

S = the cotton ply, size or number;

E = the number of ends per carrier;

C = the number of carriers;

D = the diameter under braid, in inches;

M = the space between each set of carrier threads, in inches;

$$M = X\,(0.011 + 7.0\,t^2E^2)$$

X = the closeness constant, Values of X:

Values of X	DIAMETER UNDER BRAID, IN.
1.1......	0 to 0.500
1.0......	0.501 and over

For convenience in calculating the more usual braid constructions, the formula for picks may be reduced to:

$$P = \sqrt{Y - \frac{Z}{(D+T)^2}} \quad \text{where } Y = \frac{1}{(tE+M)^2} \quad \text{and } Z = \left(\frac{C}{2\pi}\right)^2$$

Values of Y for some of the most commonly used cottons are:

Size of Yarn	Thickness of Braid, T	Values of Y										
		For Diameters Under 0.500 in.				For Diameters 0.501 in. and Over						
		2 End	3 End	4 End	5 End	2 End	3 End	4 End	5 End	6 End	7 End	8 End
30/2	0.0163..................	1081	592	358	233	....	....	....	....	....	....	....
26/2	0.0175..................	982	526	312	220	....	....	....	....	....	....	....
24/2	0.0182..................	930	492	290	185	....	....	....	....	....	....	....
20/2	0.0200..................	807	416	241	151	878	446	259	163	....	....	....
16/2	0.0223..................	683	339	193	118	738	365	207	127	....	....	....
14/2	0.0238..................	616	302	168	103	664	324	180	111	....	....	....
12/2	0.0258..................	538	257	142	85	582	276	152	92	59	40	28
10/2	0.0282..................	....	....	....	....	497	231	125	74	48	32	22
8/2	0.0316..................	....	....	....	....	407	183	96	56	35	23	16

Values of Z for the standard braiders are:

NUMBER OF CARRIERS	VALUES OF Z
12..	3.65
16..	6.49
20..	10.13
24..	14.59
36..	32.80
48..	58.40

(*d*) For braid over twin wires use 1.64 times the conductor diameter to determine the proper braid.

(*e*) Where two braids are specified, the outer braid shall be determined by the diameter over the inner braid. Where the diameter change-over limit is such that Table IX or Table X and this section require different sizes of yarn on the inner and outer braids, both braids may be of the size of yarn as required on the outer braid.

(*f*) Where two braids are applied in one operation, these specifications shall apply to the inner and outer braids except that picks per inch and angle of braid for inner braid shall be governed by the construction of the machine.

(*g*) These specifications do not apply to braids for fixture wire or to fancy or special braids.

Table XI.—Braid.

Diameter Under Braid, *D*, in.	Size and Ply of Cotton Yarn, Minimum	No. of Ends	Thickness of Braid, Minimum, in.	Diameter, Mean Avg. $(D+T)$, in.	12-Carrier Braiders		16-Carrier Braiders		20-Carrier Braiders		24-Carrier Braiders		36-Carrier Braiders		48-Carrier Braiders	
					Picks per inch	Braid Angle, deg.	Picks per inch	Braid Angle, deg.	Picks per inch	Braid Angle, deg.	Picks per inch	Braid Angle, deg.	Picks per inch	Braid Angle, deg.	Picks per inch	Braid Angle, deg.
Standard Braid																
0.090	30/2	2	0.0163	0.106	27.7	57.0	22.6	43.0	....	....	....	....	....	....	....	....
0.091 to 0.110	30/2	2	0.0163	0.116	28.6	60.0	24.7	48.0	....	....	....	....	....	....	....	....
0.111 to 0.125	30/2	2	0.0163	0.134	29.8	65.0	27.0	55.0	23.0	44.0	....	....	....	....	....	....
0.126 to 0.150	30/2	2	0.0163	0.154	30.6	68.0	28.6	60.0	25.8	51.0	....	....	....	....	....	....
0.151 to 0.175	30/2	2	0.0163	0.179	31.2	71.0	29.8	64.0	27.8	58.0	....	....	....	....	....	....
0.176 to 0.200	30/2	2	0.0163	0.204	31.6	73.0	30.6	68.0	29.1	62.0	....	....	....	....	....	....
0.201 to 0.225	26/2	2	0.0175	0.231	30.2	74.3	29.3	69.4	28.1	63.9	26.6	58.1	....	....	....	....
0.226 to 0.250	26/2	2	0.0175	0.256	30.4	76.2	29.7	71.5	28.8	66.7	27.6	61.6	....	....	....	....
0.251 to 0.300	26/2	2	0.0175	0.293	30.4	78.0	30.2	74.0	29.5	70.0	28.6	65.0	....	....	....	....
0.301 to 0.350	26/2	2	0.0175	0.343	....	....	....	....	30.0	73.0	29.4	69.0	....	....	....	....
0.351 to 0.400	20/2	3	0.020	0.396	....	....	....	....	18.8	66.0	18.0	62.0	....	....	....	....
0.401 to 0.450	20/2	3	0.020	0.445	....	....	....	....	19.1	70.0	18.5	65.0	....	....	....	....
0.451 to 0.500	20/2	3	0.020	0.495	....	....	....	....	19.4	72.0	18.9	68.0	....	....	....	....
0.501 to 0 600	20/2	3	0.020	0.570	....	....	....	....	20.4	75.0	20.1	72.0	....	....	....	....
0.601 to 0.800	20/2	3	0.020	0.720	....	....	....	....	20.6	78.0	20.5	76.0	....	....	....	....
0.801 to 1.000	12/2	4	0.0258	0.925	....	....	....	....	11.8	73.7	11.6	70.3	10.7	59.8	9.2	48.6
1.001 to 1.200	12/2	4	0.0258	1.125	....	....	....	....	12.0	76.8	11.9	74.0	11.2	65.7	10.3	56.0
1.201 to 1.500	12/2	4	0.0258	1.376	....	....	....	....	....	....	12.0	77.0	11.6	70.2	11.0	63.2
1 501 to 2.000	8/2	5	0.0316	1.782	....	....	....	....	....	....	7.2	73.3	6.8	64.6	6.1	55.0
2.001 to 3.000	8/2	5	0.0316	2.532	....	....	....	....	....	....	7.3	78.2	7.1	72.2	6.9	66.2
Heavy Braid																
0.090	20/2	2	0.020	0.110	22.6	52.5	16.5	35.5	....	....	....	....	....	....	....	....
0.091 to 0.110	20/2	2	0.020	0.120	23.6	56.0	18.9	41.7	....	....	....	....	....	....	....	....
0.111 to 0.125	20/2	2	0.020	0.138	24.6	58.3	21.5	49.3	....	....	....	....	....	....	....	....
0.126 to 0.150	20/2	2	0.020	0.158	25.7	64.6	23.3	55.3	20.0	44.8	....	....	....	....	....	....
0.151 to 0.175	20/2	2	0.020	0.183	26.4	67.5	24.8	60.5	22.7	52.5	19.2	42.5	....	....	....	....
0.176 to 0.200	20/2	2	0.020	0.208	26.9	70.4	27.5	65.8	23.7	57.0	21.6	49.5	....	....	....	....
0.201 to 0.225	16/2	2	0.0223	0.235	....	....	23.8	56.5	22.4	58.8	20.4	51.5	....	....	....	....
0.226 to 0.250	16/2	2	0.0223	0.260	....	....	25.8	77.8	23.0	62.0	21.6	55.6	....	....	....	....
0.251 to 0.300	16/2	3	0.0223	0.297	....	....	16.3	62.3	15.0	54.5	13.2	49.5	....	....	....	....
0.301 to 0.350	12/2	3	0.0258	0.351	....	....	....	....	13.2	55.4	11.8	47.3	....	....	....	....
0.351 to 0.400	12/2	3	0.0258	0.401	....	....	....	....	13.9	60.1	12.9	53.5	....	....	....	....
0.401 to 0.450	12/2	3	0.0258	0.451	....	....	....	....	14.4	63.9	13.6	58.1	....	....	....	....
0.451 to 0.500	12/2	3	0.0258	0.501	....	....	....	....	14.7	66.6	14.1	62.0	....	....	....	....
0.501 to 0.600	12/2	3	0.0258	0.576	....	....	....	....	....	....	15.2	66.4	13.3	55.7	....	....
0.601 to 0.800	8/2	3	0.0316	0.732	....	....	....	....	....	....	12.5	67.3	11.1	57.2	....	....
0.801 to 1.000	8/2	3	0.0316	0.932	....	....	....	....	....	....	12.9	72.3	12.0	65.0	10.8	53.0
1.001 to 1.200	6/2	2	0.037	1.137	....	....	....	....	....	....	....	....	17.0	74.9	16.4	67.7
1.201 to 1.500	6/2	2	0.037	1.387	....	....	....	....	....	....	....	....	17.2	77.7	16.8	71.8
1.501 to 2.000	4/2	3	0.0446	1.795	....	....	....	....	....	....	....	....	8.6	71.3	8.1	62.3
2.001 to 3.000	4/3	3	0.0556	2.556	....	....	....	....	....	....	....	....	6.6	72.8	6.3	64.5

(*h*) In Table XI are tabulated the required picks per inch as calculated by the formula in Paragraph (*c*) and the corresponding braid angle for braids applied with the minimum size and ply of cotton, and a definite number of ends per carrier. However, it is not the intent of these specifications to limit the braids to the scope of Table XI since heavier cottons or a variation in ends per carrier are permissible providing all requirements of Sections 58 and 59 are fulfilled.

Measurements

60. The various quantities shall be determined as follows:

Diameter Under Braid, by a suitable micrometer reading.

Number of Carriers and *Ends per Carrier*, by examination of braid.

Picks per Inch, on a 4-in. sample after wiping off outside of braid with chloroform.

Angle of Braid by formula: Tangent of Angle $= \dfrac{2\pi P\,(D + T)}{C}$

Thickness of Braid (2 × diameter of single end of cotton), by measuring 25 per cent of the total number of threads with a paper micrometer having a foot 0.4 in. in diameter under a weight of 50 g. The sample of braid on which the average diameter is determined shall be prepared by immersing a 2-in. length of sample in chloroform in a suitable container for 5 minutes, decanting and repeating for 1 minute, and removing and drying it thoroughly by pressing it between cheese cloth.

Number of Tests

61. Samples shall be taken at the option of the purchaser.

(*E*) FINISH

Finish

62. The braid shall be completely saturated and finished with a black moisture-resistant compound. The surface of the wire shall be smooth and free from tackiness. The finish shall be capable of meeting the tests described in Sections 63 to 67, inclusive. Single conductor 600-v. wire for building purposes is required by the National Electrical Code to have a flame-proof finish. Where Underwriters jurisdiction applies the finish and tests shall be in accordance with Underwriters standards.

Bend Test

63. (*a*) *Sample.*—Each sample for the bend test shall be wrapped as specified in Paragraph (*b*) around a mandrel of the diameter given in the following table:

DIAMETER OF SAMPLE, IN.	RATIO OF MANDREL DIAMETER TO OUTSIDE DIAMETER OF WIRE OR CABLE
0 to 0.250	1½
0.251 to 0.375	2¼
0.376 to 0.500	3
0.501 to 0.750	4½
0.751 to 1.000	6
1.001 to 1.500	9
1.501 and up	12

(*b*) *Test Procedure.*—The samples shall be held at a temperature of 32 F. (0 C.) for approximately 1 hr. before bending, and upon removal from the cooling chamber shall be wrapped upon the mandrel at an approximately uniform rate not greater than 12 turns per minute. Single conductor No. 2 A.w.g. and smaller shall be wrapped three times around the mandrel; when requested single conductor wires larger than No. 2 A.w.g. and any multiple conductor shall be wrapped once around the mandrel.

(*c*) *Flaking and Cracking.*—The finishing material shall not flake off the wire or cable during the bend test or as a result of the bend test without actually rubbing the surface of the wire. Cracking of the finish will not be cause for rejection.

Melt Test

64. A piece of clean white glazed paper shall be wrapped around a 6-in. sample of finished wire or cable and this shall be suspended horizontally in an electrically heated oven, equipped with suitable automatic temperature control, which has been heated to 125 F. (52 C.) and the wire or cable shall be maintained at this temperature for 30 min. The wire or cable with the paper wrapping shall be cooled before inspection. The wire shall be rejected if the compound becomes sufficiently fluid to be transferred to the paper or form a ridge perceptible to the finger upon it.

Drip Test

65. Samples for the drip test shall be cut in lengths of 6 in. and the wire bared for a distance of ¾ in. from each end. The sample with one end secured in a suitable clamp shall then be suspended at an angle of 45 deg. in an electrically heated oven, equipped with suitable automatic temperature control, which has been heated to 180 F. (82.2 C.) and the wire or cable shall be maintained at this temperature for 1 hr. At the end of this time the compound shall not have dripped, flowed onto the surface of the lower bared end of the conductor, formed globules on the lower side of the sample or bubbles upon its surface.

Moisture Absorption Test

66. (*a*) The moisture absorption shall not exceed 15 per cent when determined in accordance with Paragraphs (*b*) and (*c*).

(*b*) *Sample.*—A sample of finished wire, 24 in. in length, shall be bent around a mandrel, the diameter of which shall be determined from the over-all diameter of the wire, as follows:

DIAMETER OF SAMPLE, IN.	DIAMETER OF MANDREL	BEND, DEG.
0 to 0.250	1½ times diameter of sample	360
0.251 to 0.375	2¼ times diameter of sample	360
0.376 to 0.500	3 times diameter of sample	360
0.501 to 0.750	4½ times diameter of sample	180
0.751 to 1.000	6 times diameter of sample	180
1.001 to 1.500	9 times diameter of sample	180
1.501 and up	12 times diameter of sample	180

As many turns as possible of sizes No. 2 A.w.g. and smaller shall be made about the mandrel, leaving the free ends of such length as to permit 2 in. of each end to be exposed when the samples are subsequently immersed. Sizes larger than No. 2 shall be bent in the form of a "U" about the mandrel specified.

(*c*) *Test Procedure.*—The flexed samples shall be removed from the mandrel and exposed in free air at a temperature of from 20 to 25 C. for at least 48 hr. and then carefully weighed. This weight shall be recorded as W. The flexed samples shall then be immersed in distilled water at 20 to 25 C. in such a manner that the flexed portion of the sample is completely covered with water and the free ends projecting 2 in. above the surface of the water. The samples shall be allowed to remain immersed for a period of 72 hr. at room temperature. At the end of the immersion period the samples shall all be removed, rinsed in pure alcohol for not over 5 sec., and allowed to dry in air for not over 5 min., to allow the surface water to evaporate. Sizes No. 1 A.w.g. and larger may be dried by wiping with a dry cloth. The 24-in. sample shall then be immediately weighed. This weight should be recorded as W_1. After weighing, all coverings shall be removed from the insulation and the conductor and insulation weighed. This weight shall be recorded as W_2.

(*d*) *Calculation of Results.*—The moisture absorbed in terms of percentage by weight of fibrous coverings shall be calculated by the following formula:

$$\text{Percentage Moisture Absorption} = \frac{100\,(W_1 - W)}{W - W_2}$$

Saturating and Finishing Compounds

67. The saturating and finishing compounds shall have no injurious effect upon the rubber insulation or the coverings during application.

TABLE XII.—THICKNESS OF LEAD SHEATHS.

DIAMETER OF CORE, IN.[a]	THICKNESS OF SHEATH IN SIXTY-FOURTHS OF AN INCH
Over 3.000	9
2.001 to 3.000	8
1.501 to 2.000	7
1.051 to 1.500	6
0.701 to 1.050	5
0.426 to 0.700	4
0.000 to 0.425	3

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[a] For twin cables, use the major axis.

(*F*) LEAD SHEATHS

Composition

68. (*a*) Lead sheaths shall consist of Grade II Chemical Lead or Grade III Common Lead not less than 99.85 per cent pure as specified

in the Standard Specifications for Pig Lead (A.S.T.M. Designation: B 29) of the American Society for Testing Materials.[1] It shall be obtained from properly branded pig lead.

(*b*) Lead sheaths shall be tightly formed around the core of the wire or cable.

Thickness

69. Lead sheaths shall have an average thickness not less than that indicated in Table XII and the minimum thickness shall in no place be less than 90 per cent of the required average thickness.

Measurement

70. A short section of the lead sheath shall be removed from the wire or cable and the thickness measured with a suitable micrometer caliper at not less than ten points, approximately equally spaced, care being taken to include the thinnest and the thickest parts.

(*G*) INSPECTION AND REJECTION

Inspection and Test

71. (*a*) Inspection shall be made prior to shipment and at the place of manufacture.

(*b*) The manufacturer shall notify the purchaser sufficiently in advance of the completion of the wire or cable to permit of arrangement of inspection.

(*c*) The inspector representing the purchaser shall have free entry at all times, while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the wire ordered, except compounding room. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the wire is being furnished in accordance with these specifications.

(*d*) The purchaser at his option may make the various tests on samples in his own laboratory or elsewhere, but such tests shall be made at the expense of the purchaser.

Rejection

72. Each coil, reel or length which fails to comply with the physical and electrical requirements of these specifications shall be rejected.

Rehearing

73. Samples of rejected material shall be preserved for two weeks from date of test report. In case of dissatisfaction with the results

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[1] 1936 Book of A.S.T.M. Standards, Part I, p. 678.

of test, the manufacturer may make claim for a rehearing within that time. Sealed duplicate samples may be retained by the manufacturer at his option.

APPENDIX I

ANNEALED COPPER STANDARD[1]

The following shall be taken as normal values for standard annealed copper:

(*a*) *Resistance.*—At a temperature of 20° C. the resistance of a wire of standard annealed copper 1 meter in length and of a uniform section of 1 sq. mm. is $\frac{1}{58}$ ohm = 0.017241 ohm.

(*b*) *Density.*—At a temperature of 20° C. the density of standard annealed copper is 8.89 g. per cu. cm.

(*c*) *Temperature Coefficient of Resistance.*—At a temperature of 20° C. the "constant mass" temperature coefficient of resistance of standard annealed copper, measured between two potential points rigidly fixed to the wire, is 0.00393 = 1/254.45 per degree Centigrade.

(*d*) Other values of resistivity of standard annealed copper at 20° C. deduced from Paragraphs (*a*) and (*b*) are as follows:

Resistance of a wire of uniform section, 1 meter long and weighing 1 g. = 0.15328 ohm.

Resistance of a wire with a uniform section of 1 cir. mil and 1 ft. long = 10.371 ohm.

Resistance between opposite faces of 1 cu. cm. = 1.7241 microhm.

Resistance between opposite faces of 1 cu. in. = 0.67879 microhm.

APPENDIX II

INTERPRETATION OF INSULATION THICKNESSES OF TABLE IV

For series-street-lighting cable, use the following procedure:

A1. (*a*) If the transformer is not equipped with protectors, use the open circuit secondary voltage of the transformer as rated voltage of the cable and select the proper wall thickness from Table IV.

(*b*) If the transformer is equipped with protectors, use the closed or loaded secondary voltage of the transformer as the rated circuit voltage of the cable and select the proper wall thickness from Table IV.

NOTE.—It is preferable, both in Paragraphs (*a*) and (*b*) above, to select a cable with a higher voltage rating than obtained using the above procedure, both as a measure of safety and to allow the substitution of a larger transformer without necessitating the replacement of the cable.

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[1] Extracts from American Institute of Electrical Engineers' Standard No. 30 (1932).

The thickness of insulation for the various systems shall be determined as follows:

A2. (*a*) For three-phase systems with grounded or ungrounded neutral, use thickness values in accordance with Table IV.

(*b*) For single or two-phase systems up to and including 5000 v., use thickness values in accordance with Table IV, as specified for grounded neutral. Where it is not definitely specified that a line operates as an isolated single or two-phase system it shall be considered as a branch of a grounded three-phase circuit and the thickness of insulation shall be that required by the phase-to-phase voltage of this grounded, three-phase circuit as given in Table IV.

(*c*) For single or two-phase systems operating at over 5000 v. with one side grounded, multiply the circuit voltage (phase-to-phase) by 1.73 and use the resulting voltage value to select the corresponding insulation thickness for grounded neutral as specified in Table IV.

(*d*) For single or two-phase systems operating at over 5000 v. with the center grounded, multiply the circuit voltage (phase-to-phase) by 0.866 ($\frac{1}{2}\sqrt{3}$) and use the resulting voltage value to select the corresponding insulation thickness for grounded neutral as specified in Table IV.

(*e*) For single or two-phase ungrounded systems operating at over 5000 v., multiply the circuit voltage (phase-to-phase) by 0.866 ($\frac{1}{2}\sqrt{3}$) and use the resulting voltage value to select the corresponding insulation thickness for ungrounded neutral as specified in Table IV.

(*f*) For direct-current systems, consider them the same as single-phase alternating-current systems in accordance with Paragraph A2 (*b*).

TENTATIVE SPECIFICATIONS
FOR
INSULATED WIRE AND CABLE: PERFORMANCE RUBBER COMPOUND[1]

A.S.T.M. Designation: D 353 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1932; REVISED, 1933, 1934, 1935, 1936.[2]

Scope

1. (*a*) These specifications cover wire and cable insulated with a vulcanized rubber compound. The suitability of the compound as insulation shall be determined solely by physical and electrical tests. The compound shall be called performance rubber compound.

(*b*) Except for the rubber insulation and methods of testing, wire and cable supplied under these specifications shall conform to the Tentative Specifications for Insulated Wire and Cable: Class AO, 30 per cent Hevea Rubber Compound (A.S.T.M. Designation: D 27 - 36 T) of the American Society for Testing Materials.[3]

INSULATION

Workmanship

2. (*a*) The insulation shall be homogeneous in character, tough, elastic and applied concentrically about the conductor and shall fit tightly thereto. Where the insulation is applied in more than one layer adjacent layers shall be vulcanized into a homogeneous mass.

(*b*) *Shielding.*—Braided cables not supported on insulators when operating at 6001 v. and over with the neutral grounded or 3501 v. and over with the neutral ungrounded shall be shielded or suitably protected against corona. For special installations, such as braided cables connected to an overhead line, shielding may be provided at voltages lower than those given herein.

All lead-covered multiple conductor cables operating at 6001 v. and over with the neutral ungrounded shall be shielded or suitably protected against corona.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-11 on Rubber Products.

[2] Latest revision accepted by Committee E-10 on Standards, August 26, 1936.

[3] See p. 1065.

The shielding shall consist of a thin tinned copper tape or braid of fine tinned copper wires.

(*c*) The insulation of braided wires up to No. 7 A. w. g., inclusive, shall be covered with a single cotton braid. On larger sizes the fibrous covering shall consist of a cable tape and cotton braid or two cotton braids. The cable tape may be applied before vulcanization. In multiple conductor cables the individual conductors shall not be braid-covered unless specified.

(*d*) Where repairs or joints are made in the insulation, the work shall be done in such manner that the repaired part of the joint, and all parts affected in the process, shall be as strong and durable electrically and mechanically as the remainder of the insulation and shall not exceed the limitations on the thickness specified in Section 5.

MANUFACTURE

Composition

3. The insulation shall consist of a properly vulcanized rubber compound that will meet the tests hereinafter specified.

PHYSICAL PROPERTIES

Physical Properties

4. The insulation shall conform to the following requirements as to physical properties:

	MAXIMUM	MINIMUM
Tensile strength, lb. per sq. in.	..	1200
Tensile stress at 200 per cent elongation, lb. per sq. in.	..	300
Elongation at rupture, per cent	..	400
Set in 2-in. gage length, in.	$\frac{3}{8}$	....
Depreciation in tensile strength and elongation after oxygen bomb test, per cent	25	....
Depreciation in tensile strength and elongation after Geer oven test, per cent	15	....

THICKNESS

Thickness

5. (*a*) The average thickness of the insulation shall be not less than that given in Table I. The minimum thickness shall be not less than 95 per cent of the thickness required by Table I for insulations less than $\frac{4}{64}$ in. in thickness and not less than 90 per cent of the specified thickness for insulations of $\frac{4}{64}$ in. and greater.

(*b*) The thicknesses in Table I apply to single conductor cable and the individual conductors of multiple conductor cables, leaded or braided, except special applications such as aerial, non-leaded submarine, and vertical riser cable.

Note.—In Appendix I will be found an interpretation of the insulation thicknesses given in Table I.

TABLE I.—THICKNESS OF INSULATION AND ALTERNATING TEST VOLTAGE

NOTE 1.—Rated circuit voltage of alternating-current circuits is the phase-to-phase voltage.

NOTE 2.—For an intermediate size of wire or an intermediate rated circuit voltage, the thickness and test voltage shall be that for the next larger size or higher rated circuit voltage.

NOTE 3.—For non-leaded submarine cables, $\frac{1}{32}$ in. should be added to the specified respective walls of insulation in this table for all sizes and voltages.

NOTE 4.—Rated circuit voltages from 0 to 5000 v. in this table apply to wire for use on grounded and ungrounded circuits.

NOTE 5.—Above 5000 v. alternating-current, special high-voltage rubber compounds are preferred according to manufacturer's recommendations.

Rated Circuit Voltage	Size of Conductor, A. w. g. Numbers or Circular Mils	Insulation Thickness on each Conductor, sixty-fourths of an inch	Test Voltage
0 to 300	No. 18 to No. 16	2	1 000
0 to 600	No. 14 to No. 9	3	3 000
	No. 8 to No. 2	4	3 500
	No. 1 to No. 0000	5	4 000
	225 000 to 500 000 cir. mils	6	5 000
	525 000 to 1 000 000 cir. mils	7	6 000
	Over 1 000 000 cir. mils	8	7 000
601 to 1000	No. 14 to No. 8	4	5 000
	No. 7 to No. 2	5	6 000
	No. 1 to No. 0000	6	7 500
	225 000 to 500 000 cir. mils	7	9 000
	525 000 to 1 000 000 cir. mils	8	10 000
	Over 1 000 000 cir. mils	9	11 000
1001 to 2000	No. 14 to No. 8	5	6 000
	No. 7 to No. 2	6	7 500
	No. 1 to No. 0000	7	9 000
	225 000 to 500 000 cir. mils	8	10 000
	525 000 to 1 000 000 cir. mils	9	11 000
	Over 1 000 000 cir. mils	9	11 000
2001 to 3000	No. 14 to No. 8	7	9 000
	No. 7 to No. 2	8	10 000
	No. 1 to No. 0000	8	10 000
	225 000 to 500 000 cir. mils	9	11 000
	525 000 to 1 000 000 cir. mils	9	11 000
	Over 1 000 000 cir. mils	10	12 500
3001 to 4000	No. 14 to No. 8	9	11 000
	No. 7 to No. 2	9	11 000
	No. 1 to No. 0000	9	11 000
	225 000 to 500 000 cir. mils	10	12 500
	525 000 to 1 000 000 cir. mils	10	12 500
	Over 1 000 000 cir. mils	11	13 500
4001 to 5000	No. 14 to No. 8	10	12 500
	No. 7 to No. 2	10	12 500
	No. 1 to No. 0000	10	12 500
	225 000 to 500 000 cir. mils	11	13 500
	525 000 to 1 000 000 cir. mils	11	13 500
	Over 1 000 000 cir. mils	12	15 000
5001 to 6000 (grounded)	No. 14 to No. 0000	10	12 500
	225 000 to 1 000 000 cir. mils	11	13 500
	Over 1 000 000 cir. mils	12	15 000
5001 to 6000 (ungrounded)	No. 14 to No. 0000	12	15 000
	225 000 to 1 000 000 cir. mils	12	15 000
	Over 1 000 000 cir. mils	13	16 500
6001 to 7000 (grounded)	No. 8 to No. 0000	11	13 500
	225 000 to 1 000 000 cir. mils	11	13 500
	Over 1 000 000 cir. mils	12	15 000
6001 to 7000 (ungrounded)	No. 8 to No. 0000	14	17 500
	225 000 to 1 000 000 cir. mils	14	17 500
	Over 1 000 000 cir. mils	15	19 000
7001 to 8000 (grounded)	No. 8 to No. 0000	12	15 000
	225 000 to 1 000 000 cir. mils	12	15 000
	Over 1 000 000 cir. mils	13	16 500
7001 to 8000 (ungrounded)	No. 8 to No. 0000	16	20 000
	225 000 to 1 000 000 cir. mils	16	20 000
	Over 1 000 000 cir. mils	17	21 000

ELECTRICAL PROPERTIES

High Voltage Test

6. Each coil, reel, or length of wire or cable after vulcanization shall successfully withstand the application of an alternating voltage of not less than that prescribed in Table I for a period of 5 minutes. (See Sections 30 and 31.)

Insulation Resistance

7. Each coil, reel, or length of wire or cable after being subjected to the high voltage test specified in Section 6 shall have an insulation resistance not less than that given in Table II.

Moisture Absorption.

8. (*a*) The increase in the specific inductive capacity of the insulation shall be used as an indication of the amount of moisture absorbed.

(*b*) The specific inductive capacity after 24-hr. immersion in water shall not exceed six. The increase between the ends of the first and the fourteenth days shall not exceed 20 per cent and that between the ends of the seventh and fourteenth days, 5 per cent.

(*c*) The specific inductive capacity shall be determined at either 1000 or 60 cycles. Where measured at 1000 cycles, the voltage impressed upon the conductor shall not exceed 10 volts. Where measured at 60 cycles, the voltage impressed upon the conductor shall be equivalent to a stress of between 30 to 40 volts per mil of insulation.

(*d*) The measurements shall be made as described in Section 35.

METHODS OF TESTING

TENSILE STRENGTH, SET, AND ELONGATION AT RUPTURE

Sampling for Physical Tests

9. (*a*) Wire up to and including 250,000 cir. mils in size shall be sampled in accordance with the following requirements:

	NUMBER OF SAMPLES
2000 ft. and under	none
2001 to 10,000 ft.	1 for each 2000 ft. or fraction thereof
10,001 to 100,000 ft.	5 plus 1 for each 10,000 ft. additional over 10,000 ft.
100,001 to 500,000 ft.	14 plus 1 for each 25,000 ft. over 100,000 ft.

(*b*) For wire larger than 250,000 cir. mils, one sample shall be selected from quantities between 1000 and 2000 ft. and for larger quantities double those specified in Paragraph (*a*).

Test Specimens

10. (*a*) *Size.*—For the physical tests, the test specimen may be the entire cross-section of the insulation in the case of small wires,

or, in the case of a large wire or cable, either a segment or sector cut with a sharp knife held tangentially to the conductor or a shaped specimen cut out with a standard die. The test specimen shall be as free as possible from surface incisions and imperfections. There shall be no limit to the cross-section of the test specimen, except as restricted by the capacity of the testing machine.

TABLE II.—INSULATION RESISTANCE, MEGOHMS-1000 FT. AT 60° F. (15.5° C.).

NOTE 1.—This table is based on a constant, $K = 21\,120$ in the following formula:

$R = K \log_{10}\frac{D}{d}$; where R = resistance in megohms-1000 ft., K = constant,

D = diameter over insulation, on each conductor, and d = diameter over conductor.

NOTE 2.—For an intermediate size, the insulation resistance shall be that of the next larger size.

Size of Conductor, A. w. g. Numbers or Circular Mils	Solid or Stranded	Diameter in Inches	Insulation Thickness in Sixty-fourths of an Inch									
			2	3	4	5	6	7	8	9	10	12
No. 18	Solid	0.040	8 600	11 100	....	....	....	....	....	....	....	....
No. 16	Solid	0.051	7 300	9 500	....	....	....	....	....	....	....	....
No. 14	Solid	0.064	....	8 300	9 900	11 300	12 550	13 650	14 600	15 450	16 250	17 650
No. 12	Solid	0.081	....	7 050	8 550	9 850	11 000	12 000	12 900	13 750	14 500	15 850
No. 10	Solid	0.102	....	6 000	7 350	8 500	9 600	10 500	11 350	12 100	12 850	14 150
No. 8	Solid	0.128	....	....	6 200	7 300	8 300	9 150	9 950	10 650	11 350	12 550
No. 6	Stranded	0.184	....	....	4 750	5 600	6 400	7 200	7 900	8 500	9 100	10 200
No. 4	Stranded	0.232	....	....	3 900	4 700	5 450	6 100	6 700	7 250	7 800	8 850
No. 2	Stranded	0.292	....	....	3 250	3 900	4 550	5 150	5 650	6 150	6 650	7 600
No. 1	Stranded	0.332	....	....	....	3 550	4 100	4 650	5 150	5 600	6 100	6 950
No. 0	Stranded	0.373	....	....	....	3 200	3 750	4 200	4 700	5 150	5 550	6 350
No. 00	Stranded	0.418	....	....	....	2 900	3 400	3 850	4 300	4 700	5 100	5 850
No. 000	Stranded	0.470	....	....	....	2 600	3 100	3 500	3 900	4 250	4 650	5 400
No. 0000	Stranded	0.528	....	....	....	2 400	2 800	3 150	3 550	3 900	4 200	4 900
250 000 cir. mils	Stranded	0.575	....	....	....	....	2 600	2 950	3 300	3 650	4 000	4 600
350 000 cir. mils	Stranded	0.681	....	....	....	....	2 250	2 550	2 850	3 150	3 450	4 000
500 000 cir. mils	Stranded	0.814	....	....	....	....	1 900	2 200	2 450	2 700	2 950	3 450
750 000 cir. mils	Stranded	0.998	....	....	....	....	....	1 800	2 050	2 250	2 500	2 900
1 000 000 cir. mils	Stranded	1.152	....	....	....	....	....	1 600	1 800	2 000	2 200	2 600
1 250 000 cir. mils	Stranded	1.289	....	....	....	....	....	....	1 600	1 800	2 000	2 350
1 500 000 cir. mils	Stranded	1.412	....	....	....	....	....	....	1 500	1 650	1 850	2 150
1 750 000 cir. mils	Stranded	1.526	....	....	....	....	....	....	1 400	1 550	1 700	2 000
2 000 000 cir. mils	Stranded	1.631	....	....	....	....	....	....	1 300	1 500	1 600	1 900

NOTE.—The removal of the rubber insulation can be greatly accelerated and in most cases a test specimen which is an entire cross-section can be obtained free from surface incisions and imperfections by means of metallic mercury. The mercury should be introduced at one end of the sample between the insulation and the tinned surface of the conductor, and the sample inclined on a support with the end to which the mercury is applied at the top. The separation of the rubber insulation results from the amalgamation of the tin of the conductor with the mercury. The amalgamation is assisted by first immersing and rubbing the tinning on the exposed end of the conductor in the mercury.

(*b*) *Condition and Age.*—Specimens shall not be heated, immersed in water or subjected to any mechanical or chemical treatment not specifically prescribed in these specifications.

Specimens for accelerated aging tests shall be taken from the completed wire after the application of the specified covering and shall be aged with all such covering removed.

No tests shall be made within 24 hours nor later than 60 days after vulcanization unless agreed to by the manufacturer.

(*c*) *Buffing.*—In the event of any irregularities on the surface of the test specimen, it shall be made smooth and of uniform thickness within 5 per cent of the original thickness by buffing, except when large strands are used, in which case the rubber sample shall be buffed sufficiently to remove all corrugations.

Calculation of Area

11. Calculation of the area of the test specimens shall be made as follows:

(*a*) Where the total cross-section of the insulation is used, the area shall be taken as the difference between the area of the circle whose diameter is the average outside diameter of the insulation and the area of the conductor. The area of the stranded conductor shall be calculated from its maximum diameter.

(*b*) Where a segment or sector of the insulation has to be taken in the case of a large wire or cable or where the insulation is thin, the area shall be calculated as the thickness times the width. (This applies either to a straight test specimen or one stamped out with a die, and assumes that corrugations have been removed by buffing.)

Temperature at Test

12. Physical tests shall be made at a room temperature not less than 65° F. (18.3° C.) nor more than 90° F. (32.2° C.) and the test specimen shall have been kept at the room temperature not less than 30 minutes prior to the test.

Tension Testing Machine

13. The tension testing machine shall be power-driven and preferably of the pendulum type. The machine shall be accurate within 1 per cent of the breaking load. A spring balance type of apparatus may be used if provided with a device which will indicate the actual maximum load at which rupture takes place and if provision is made to prevent recoil of the spring.

Tensile Strength Tests

14. The tensile strength test shall be made on a specimen which has not been previously stretched. The specimen shall have a length of not less than 6 in., and shall be marked with gage marks 2 in. apart and placed in the jaws of the testing machine with a maximum distance between jaws of 4 in. The specimen shall be stretched at the rate of 20 in. per minute (jaw speed) until it breaks. The test

specimen shall break between the gage marks. The tensile strength shall be calculated upon the area of the original specimen.

Tensile Stress Test

15. The tensile stress test shall be made simultaneously with the tensile strength test by recording the load when the 2-in. gage length marks are 6 in. apart, that is, at 200 per cent elongation. The tensile stress shall be calculated upon the area of the original specimen.

Elongation at Rupture

16. Elongation at rupture shall be determined simultaneously with the tensile strength test by reading the distance in inches between gage marks at the breaking point. The elongation at rupture shall be taken as the distance between gage marks at rupture less 2 in. (the original gage length). The percentage of elongation at rupture is the elongation in inches divided by the original gage length (2 in.) and multiplied by 100 to express as a percentage.

Set Test

17. The set test shall be made on a separate test specimen having a length of not less than 6 in. and marked with gage marks 2 in. apart. The specimen shall be placed in the jaws of the testing machine with a maximum distance between jaws of 4 in. and shall be stretched at the rate of 20 in. per minute (jaw speed) until the gage marks are 6 in. apart. The test specimen shall then be released within 5 seconds and the distance between gage marks shall be determined 1 minute after the beginning of release. The set is the difference between this length and the original 2-in. gage length.

Retests, Physical Properties

18. Where tested in accordance with Sections 14, 15, 16 and 17, if a specimen fails to conform to any one of the requirements for tensile strength, tensile stress, set, or elongation at rupture specified in Section 4, two additional specimens shall be taken from the same sample and tested, and the average of the results shall determine whether the material conforms to the requirements.

AGING TESTS

Sampling for Aging Tests

19. For aging tests the wire shall be sampled as follows:

No samples shall be selected where the quantity is less than 2000 ft. of wire or cable.

For sizes less than 250,000 cir. mils one sample shall be selected for each quantity ordered between 2000 ft. and 50,000 ft. of wire or cable and one additional sample for each additional 50,000 ft. thereafter.

For sizes 250,000 cir. mils and over one sample shall be selected for each quantity ordered between 2000 ft. and 25,000 ft. of wire or cable and one additional sample for each additional 25,000 ft. thereafter.

Test Specimens

20. Nine test specimens of similar size and shape shall be prepared from each sample selected in accordance with Section 19, three for the determination of the initial or unaged properties, three for the oxygen bomb test and three for the Geer oven test. One specimen of each three shall be tested and the other two held as spares except that where only one sample is selected all three specimens shall be tested and the average of the results reported.

Aging Test Conditions

21. (*a*) In the case of wire and cable smaller than No. 6 A.w.g. with an insulation thickness less than $\frac{3}{32}$ in., the insulation shall be heated in the oxygen bomb and in the Geer oven without removing the conductor.

(*b*) In the case of wire and cable of No. 6 A.w.g. and larger or with an insulation thickness greater than $\frac{3}{32}$ in., samples approximately square in section shall be cut from the insulation with a cross-section not greater than 0.025 sq. in.

(*c*) Die-cut samples shall be buffed before being subjected to the accelerated aging test wherever the thickness of the sample is $\frac{3}{32}$ in. or greater after buffing.

(*d*) The test specimens shall have no protective covering and shall be suspended vertically in such a manner that they will not come in contact with each other or with the sides of the bomb or oven.

(*e*) Physical tests on both the aged and unaged specimens shall be made at the same time. The aged specimens shall have a rest period of not less than 16 hours nor more than 48 hours between the completion of the aging test and determination of physical properties.

(*f*) Should the first set of specimens selected under Paragraph (*a*) fail to meet the specifications, two other sets of specimens shall be tested and if either of these sets fails, the coils, reels or lengths will be rejected.

Oxygen Bomb Test

22. The test specimens shall be heated in an atmosphere of oxygen at a pressure of 300 lb. per sq. in. at a temperature of from 157 to 159° F. for a period of 96 hours. The weight of the rubber in the bomb

shall not be over 2 g. per cu. in. of bomb space. The bomb pressure shall be reduced at a uniform rate, requiring at least two minutes, when specimens are removed. The bomb temperature shall be recorded automatically on a chart.

Geer Oven Test

23. The test specimens shall be heated at a temperature of from 157 to 159° F. for a period of 96 hours in an oven having a free circulation of fresh air. The oven temperature shall be recorded automatically on a chart.

Rejection

24. Where ten or more samples are selected in any inspection lot, all coils, reels or lengths shall be rejected if more than 10 per cent of the samples fail. If 10 per cent or less fail, each coil, reel or length may be tested and shall be accepted or rejected upon the results of such individual tests. Where the number of samples selected in any inspection lot is less than ten, all coils, reels or lengths shall be rejected if more than 20 per cent of the samples fail. If 20 per cent or less fail, each coil, reel or length may be tested and shall be accepted or rejected upon the results of such individual tests.

THICKNESS MEASUREMENTS

Apparatus

25. The thickness measurements may be made with any type of micrometer reading to 0.001 in., suitable for measurements of this character.

Number of Measurements

26. Where the lot of wire to be inspected consists of two coils or reels or less, at least one determination of the thickness shall be made on each coil or reel. Where the lot consists of more than two coils or reels and less than 20 coils or reels, at least one determination of the thickness shall be made on each of two coils or reels taken at random. If the lot consists of 20 or more coils or reels, not less than 10 per cent of the coils or reels shall be selected at random and at least one determination of the thickness made on each coil or reel so selected.

Procedure

27. The average thickness of the insulation shall be taken as one-half the difference between the mean of the maximum and minimum diameters measured at any point and the average diameter of the conductor measured at the same point. The minimum thick-

ness shall be as taken the difference between a measurement made over the conductor plus the thinnest wall and the diameter of the conductor. (The first measurement is made by "slicing off" the heavier side of the insulation.)

In the case of multiple-conductor cable, the measurements shall be made on the individual wires before being cabled.

Rejection

28. If the thickness of the insulation of any coil or reel is found to be less than the specified value, that coil or reel shall be rejected and a thickness measurement on each of the remaining coils or reels shall be made.

ELECTRICAL TESTS

Place

29. Electrical tests of wire and cable shall be made at the place of manufacture.

High Voltage Test

30. The high voltage test shall be made with alternating potential from a transformer and generator of ample capacity and in no case less than 5 kva. The frequency of the test voltage shall be not greater than 100 cycles and shall have a wave shape approximating as closely as possible a sine curve

Rate of Application

31. The initially applied voltage shall be not greater than the rated voltage and the rate of increase shall be approximately uniform and not over 100 per cent in 10 seconds nor less than 100 per cent in 60 seconds.

High Voltage Testing

32. (*a*) *General.*—Where insulated conductors are subjected to a high voltage test in water they shall be immersed in a grounded water bath and tested while still immersed.

(*b*) *Single Conductor.*—Single conductors shall be tested after 12 hr. immersion and without covering except a tape or braid applied before vulcanization.

Rubber sheathed conductors shall be immersed and tested after the sheath is applied.

Where a metallic sheath is applied, the conductors shall be retested against the sheath.

(*c*) *Multiple Conductor.*—The individual conductors of multiple conductor cables shall be tested before assembling as prescribed in Paragraph (*b*).

After assembly each conductor shall be tested against the adjacent conductors. Where a metallic sheath is applied each conductor shall in addition be tested against the sheath.

Cables having a rubber or other non-metallic waterproof sheath shall be immersed for 12 hr. and the conductors tested against ground. Cables covered with cable tape and braid or double braid with a weather-resistant finish shall not be immersed for testing.

Application of Voltage

33. (*a*) *Single-Conductor Cables.*—Single-conductor cables shall be tested between conductor and sheath or water in which they are immersed.

TABLE III.—TEMPERATURE COEFFICIENTS.

Temperature		Temperature Coefficient	Temperature		Temperature Coefficient
Deg. Fahrenheit	Deg. Centigrade		Deg. Fahrenheit	Deg. Centigrade	
46	7.8	0.69	61	16.1	1.03
47	8.3	0.71	62	16.7	1.05
48	8.9	0.73	63	17.2	1.08
49	9.4	0.75	64	17.8	1.11
50	10.0	0.77	65	18.3	1.14
51	10.6	0.79	66	18.9	1.17
52	11.1	0.81	67	19.4	1.20
53	11.7	0.83	68	20.0	1.23
54	12.2	0.85	69	20.6	1.26
55	12.8	0.88	70	21.1	1.30
56	13.3	0.90	71	21.7	1.33
57	13.9	0.92	72	22.2	1.37
58	14.4	0.94	73	22.8	1.40
59	15.0	0.97	74	23.3	1.44
60	15.6	1.00	75	23.9	1.48

(*b*) *Multiple-Conductor Cables.*—If a multiple-conductor cable is rated at the same operating voltage between conductor and sheath or water as between conductors, each conductor shall be tested against the other conductors in the cable and against the sheath or water, at the test voltage prescribed for that rated voltage. If a cable is rated at a voltage between conductors and ground different from that between conductors, the test between conductors shall be made at the test voltage prescribed for the rated voltage between conductors and the test between each conductor and sheath or water, shall be made at the test voltage prescribed for the rated voltage between conductors and sheath or water.

The several tests may be made by any arrangement of testing transformers suitable for the prescribed tests, such as one or more transformers supplied from a single-phase source or three transformers connected in star and supplied from a three-phase source.

Insulation Resistance

34. (*a*) The insulation resistance shall be measured after the high voltage test has been made and while the wire or cable is still immersed in water. The measurement shall be made after one minute electrification with a continuous e.m.f. of from 100 to 500 volts, the conductor being maintained negative to the water. The temperature of the water shall be within the limits given in Table III.

Temperature Coefficient

(*b*) If the temperature at which the insulation resistance was measured differs from 60° F. (15.6° C.), the resistance shall be reduced to that at 60° F. (15.6° C.) by multiplying the measured value by the coefficient in Table III corresponding to the temperature at which the measurement was made.

Moisture Absorption Test

35. (*a*) A 15-ft. sample with all the coverings removed shall be selected at random from the wire offered for inspection. The middle 10 ft. of the sample shall be immersed in distilled water for a period of 14 days with the $2\frac{1}{2}$-ft. portion at each end kept above the water as leakage insulation. The three measurements specified in Section 8 shall be taken with the water at the same temperature. The water shall be maintained at room temperature but not less than 70° F. (21° C.).

(*b*) The specific inductive capacity of the insulation shall be determined at commercial frequencies and shall be calculated as follows:

$$\text{Specific inductive capacity} = 13\,600\, C \log_{10} \frac{D}{d}$$

where C = the capacity in micro-farads of 10 ft. of sample;
D = the diameter over insulation; and
d = the diameter over conductor.

The moisture absorption test shall be made only when requested by the purchaser.

Rejection

36. Each coil, reel or length which fails to comply with the electrical requirements of these specifications shall be rejected.

APPENDIX

INTERPRETATION OF INSULATION THICKNESSES OF TABLE I

For series-street-lighting cable, use the following procedure:

A1. (*a*) If the transformer is not equipped with protectors, use the open circuit secondary voltage of the transformer as rated voltage of the cable and select the proper wall thickness from Table I.

(*b*) If the transformer is equipped with protectors, use the closed or loaded secondary voltage of the transformer as the rated circuit voltage of the cable and select the proper wall thickness from Table I.

NOTE.—It is preferable, both in Paragraphs (*a*) and (*b*) above, to select a cable with a higher voltage rating than obtained using the above procedure, both as a measure of safety and to allow the substitution of a larger transformer without necessitating the replacement of the cable.

The thickness of insulation for the various systems shall be determined as follows:

A2. (*a*) For three-phase systems with grounded or ungrounded neutral, use thickness values in accordance with Table I.

(*b*) For single or two-phase systems up to and including 5000 v., use thickness values in accordance with Table I, as specified for grounded neutral. Where it is not definitely specified that a line operates as an isolated single or two-phase system it shall be considered as a branch of a grounded three-phase circuit and the thickness of insulation shall be that required by the phase-to-phase voltage of this grounded, three-phase circuit as given in Table I.

(*c*) For single or two-phase systems operating at over 5000 v. with one side grounded, multiply the circuit voltage (phase-to-phase) by 1.73 and use the resulting voltage value to select the corresponding insulation thickness for grounded neutral as specified in Table I.

(*d*) For single or two-phase systems operating at over 5000 v. with the center grounded, multiply the circuit voltage (phase-to-phase) by 0.866 ($\frac{1}{2}\sqrt{3}$) and use the resulting voltage value to select the corresponding insulation thickness for grounded neutral as specified in Table I.

(*e*) For single or two-phase ungrounded systems operating at over 5000 v., multiply the circuit voltage (phase-to-phase) by 0.866 ($\frac{1}{2}\sqrt{3}$) and use the resulting voltage value to select the corresponding insulation thickness for ungrounded neutral as specified in Table I.

(*f*) For direct-current systems, consider them the same as single-phase alternating-current systems in accordance with Paragraph A2 (*b*) above.

TENTATIVE METHODS OF TENSION TESTING OF VULCANIZED RUBBER[1]

A.S.T.M. Designation: D 412 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1935; REVISED, 1936.

Scope

1. (*a*) These methods include standard procedures for determining stress-strain properties, tensile strength, ultimate elongation and permanent set of the usual grades of soft vulcanized rubber such as tire carcass and tread compounds or those used in most mechanical rubber goods. They do not apply to the testing of material ordinarily classed as hard rubber.

(*b*) Except as may be otherwise specified in these methods, the requirements of the Tentative Methods of Physical Testing of Rubber Products (General Requirements) (A.S.T.M. Designation: D 15 - 35 T) of the American Society for Testing Materials[2] shall be complied with and are made a part of these methods.

Description of Terms

2. (*a*) *Tensile Strength* is the tension load per unit cross-sectional area required to break a test specimen of the type and in the manner herein described.

NOTE.—Since rubber when so stressed usually stretches to a high degree with accompanying substantial reduction in cross-sectional area, and since precise measurement of the dimensions at the moment of breaking is not possible, the calculation of intensity of load is referred in all cases to the original cross-section.

(*b*) *Elongation* is the extension produced by a tension load in a section of a test specimen between gage marks placed on it, and is expressed as a percentage of the original distance between the marks. Ultimate elongation is the elongation at the moment of rupture. Elongation is also correctly designated by the term "strain."

Tensile Stress is the intensity of load referred to the original cross-section at the corresponding stated percentage of elongation which it produces. It is expressed in pounds of tension load per square inch at the particular elongation, for example, 1000 lb. per sq. in. at 500 per cent elongation, and is often designated by the term "modulus." It is used as an index of stiffness.

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-11 on Rubber Products.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1153 (1935); also 1936 Book of A.S.T.M. Tentative Standards, p. 1103.

Permanent Set refers to the extension remaining after a test specimen has been stretched and held at a specified elongation for a given period of time, relieved of load and allowed to recover during a specified interval of rest as herein described. It is expressed as a percentage of the original length and is used as an index of elasticity.

TENSION TESTING APPARATUS

Type

3. Tensile strength, elongation and stress-strain tests shall be made on a power-driven apparatus, preferably of the inclination-balance or pendulum type. A spring-balance type of apparatus may be used if provided with a device which will indicate the actual maximum load at which rupture took place and if provision is made to prevent recoil of the spring.

Requirements

4. The machine shall fulfill the following requirements:

(*a*) The applied tension as indicated by a dial or scale shall be accurate within ± 1 per cent.

(*b*) The indicator shall remain at the point of maximum load after rupture of the test specimen.

(*c*) The grips which hold the specimen in the testing machine shall be of a type which tightens automatically and exerts a uniform pressure across the gripping surface proportional to the applied tension so as to avoid uneven slipping and to insure failure of the test specimen in its constricted portion.

(*d*) The rate of travel of the power actuated grip shall be 20 in. per min. and shall be uniform at all times.

(*e*) Provision shall be made for measuring the elongation by a scale graduated to 0.1 in. and suitably attached to measuring trammel points or held back of the test specimen.

(*f*) The testing machine shall be calibrated in accordance with the provisions of Section 6.

Capacity

5. The testing machine used for a given test specimen shall be of such capacity that the maximum load required to break the specimen shall not exceed 85 per cent nor be less than 15 per cent of the rated capacity. For tests of most rubber compounds using one of the test specimens herein described a machine of 150-lb. maximum capacity will be satisfactory. For general use in tension testing of rubber, possible separation of the grips of at least 30 in. shall be provided.

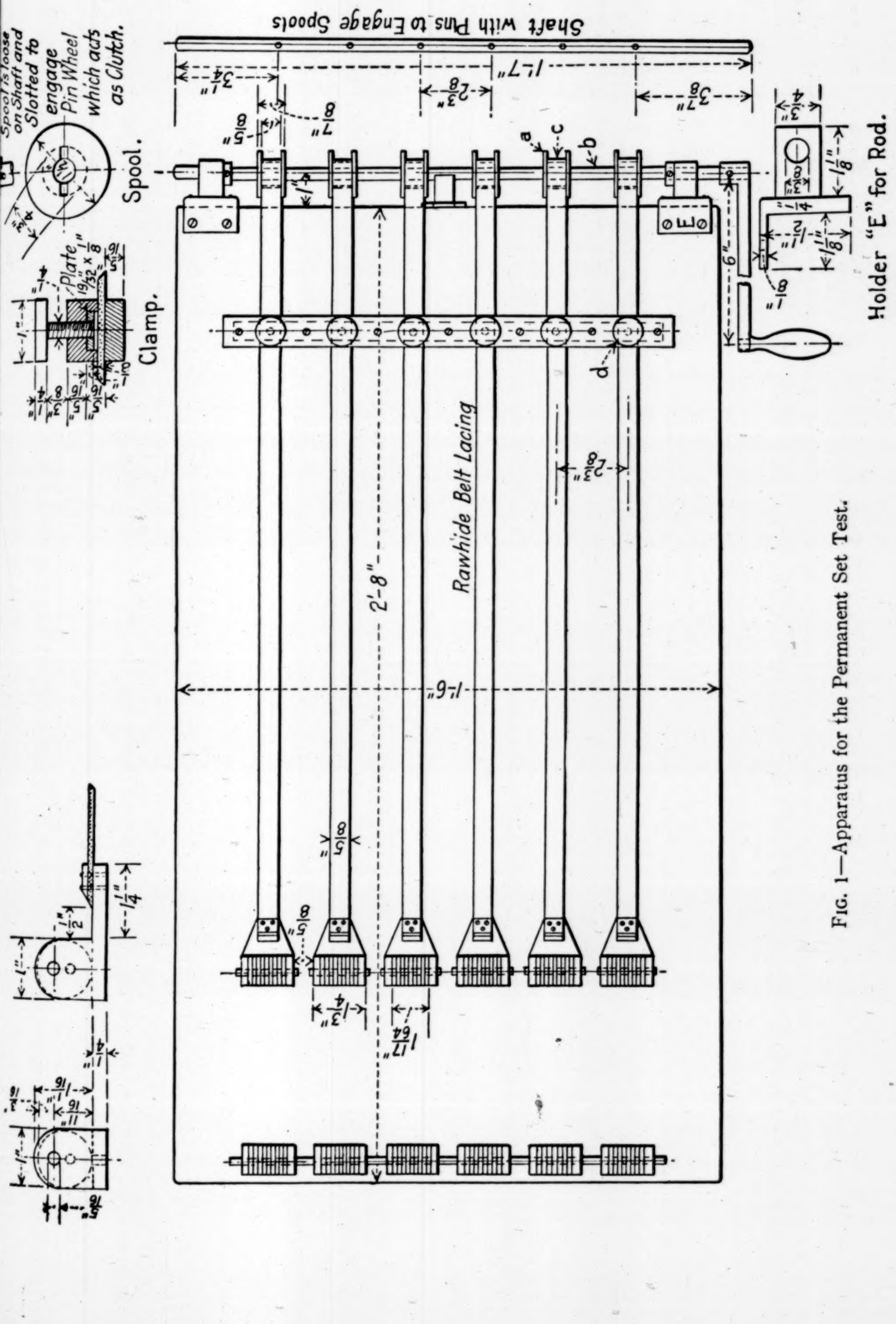
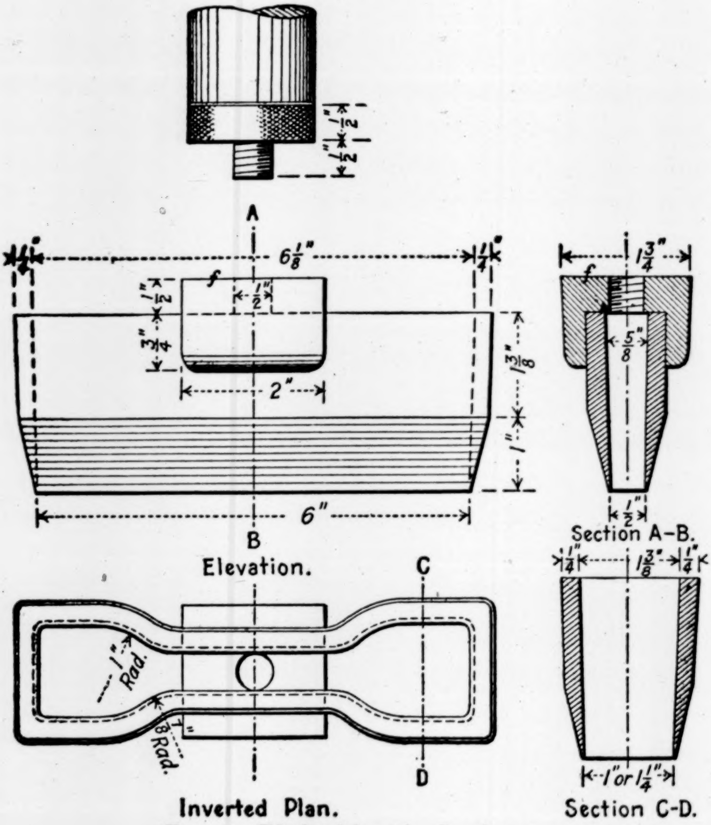

Shaft with Pins to Engage Spools
1'-7"
3/4"
2 3/8"
3 7/8"
7/8"
5/8"
1"
a
b
c
Spool.
Spool is loose on Shaft and Slotted to engage Pin Wheel which acts as Clutch.
3/4"
Plate 19/32" x 1/8"
Clamp.
E
6"
Holder "E" for Rod.
4 3/4"
1 1/8"
1/4"
1/2"
1/8"
d
2 3/8"
Rawhide Belt Lacing
2'-8"
1'-6"
5/8"
1 3/4"
1 17/64"
1/2"
1 1/4"
1"
5/16"
11/16"
1 1/16"

Fig. 1—Apparatus for the Permanent Set Test.

Calibration of Tension Testing Machines

6. Tension testing machines shall be calibrated by dead-weights applied in an ascending order while the machine is otherwise arranged in an entirely similar manner to that used when testing material. In each case when additional calibrating weight is added the weight lever of the machine shall be moved to zero position and allowed to swing slowly upwards to the point where it will go no further. The dial of the machine should then clearly indicate the amount of the weight applied.



1/2"
1/2"
A
6 1/8"
1/4"
1/4"
f
1/2"
1/2"
3/4"
2"
1 3/8"
1"
6"
B
Elevation.
1 3/4"
f
5/8"
1/2"
Section A-B.
1/4"
1 3/8"
1/4"
C
1" Rad.
1/8" Rad.
D
Inverted Plan.
1" or 1 1/4"
Section C-D.

FIG. 2.—Die for ½ by 2-in. Specimens.

Set Test Apparatus

7. Permanent set tests may be carried out on the power driven tension machine described or the special apparatus illustrated in Fig. 1 may be employed.

TEST SPECIMENS

Dies

8. Unless otherwise prescribed in the specifications for the material being tested, the specimens for tension tests shall be stamped out with a

steel die constructed substantially in accordance with Fig. 2. The dies shall be kept sharp and free from nicks to avoid leaving ragged edges on the rubber. Cutting may be facilitated by wetting the rubber surface and the cutting edges of the die. The rubber shall be rested on a smooth, slightly yielding surface which will not injure the blade. Light-weight cardboard or a piece of leather belting is suitable. Care shall be taken that the cut edges are perpendicular to the other surfaces of the specimen and have a minimum of concavity.

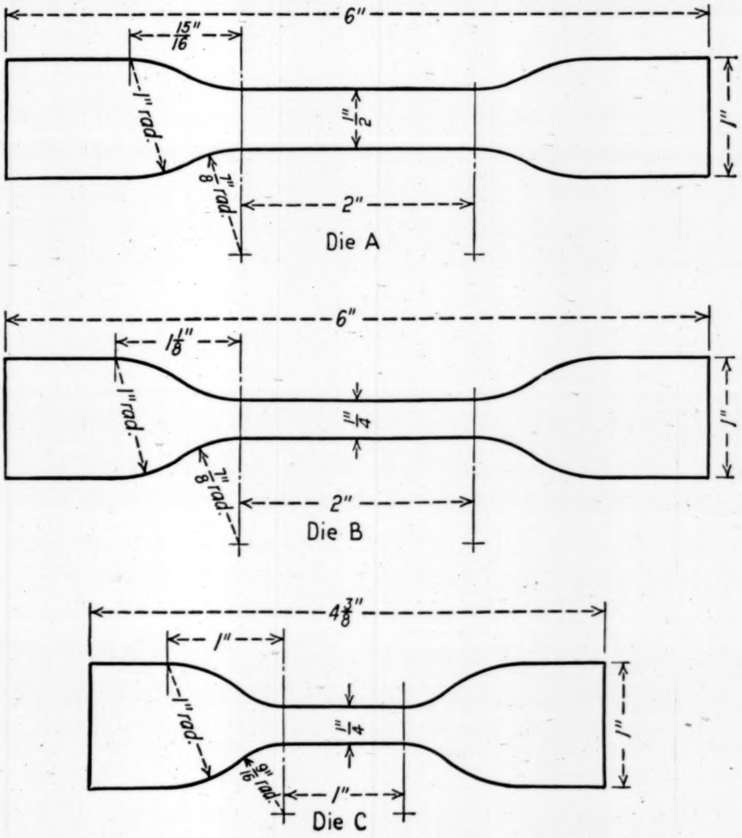


FIG. 3.—Tensile Strength and Elongation Test Specimens.

Die A shall be used when the size of the sample and the tension and stretch limits of the testing machine permit, with exceptions as explained below. If the tension limit is too high for the machine, use Die B. If the stretch is too high for the machine, use Die C. Die C shall also be used for samples which are too small for A or B. In all cases in which the sample and testing machine limitations permit a choice in die shapes, the die giving the highest test values shall be used, as such higher results will be nearer to the true value of the material.

Shape

9. The specimen stamped out shall conform in shape to Fig. 3 A, B or C, and shall not vary in width in the reduced section by more than

±0.001 in. from the dimension shown. In no case shall the thickness of the test specimen exceed $\frac{1}{8}$ in.

Gage Marks

10. Two parallel gage lines for use in determining elongation shall be marked on the reduced section perpendicular to the longitudinal axis of the specimen one on each side of the center and $\frac{1}{2}$ in. or 1 in. therefrom, as required. The marks shall be as narrow as possible consistent with legibility. Use of a stamp with parallel steel blades is recommended but care shall be taken not to injure the rubber.

Measurement of Thickness

11. (*a*) The thickness shall be measured with a micrometer graduated to 0.001 in. having a presser foot 0.25 in. ±0.01 in. in diameter exerting a total force of 9.0 oz. ±0.1 oz. The load shall be applied by means of a weight.

(*b*) The minimum thickness and width between the gage marks shall be taken in calculating the area to be used in determining the tensile strength of the specimen.

Number of Test Specimens

12. (*a*) Three specimens per sample shall be tested for determinations of tensile strength, elongation, and stress-strain properties, except as noted in Paragraph (*b*). Results on specimens which break outside of the straight reduced section or which are found to be imperfect shall be discarded and retests shall be made. In case the ultimate tensile strengths fail to check within 5 per cent of the highest value obtained, additional specimens shall be tested until two or more such check results are obtained. The final values shall be the averages of the check tests discarding the determinations on samples which are outside of the above limit.

(*b*) When minimum requirements are established as in testing for compliance with a particular specification, only one test shall be made for tensile strength, ultimate elongation or stress-strain relations. If the results are below the specified requirements, two additional specimens shall be prepared from the original sample and tested. Should the results of either of these tests be below the specified requirements, the sample shall be considered to have failed to meet the specifications.

(*c*) Two specimens per sample shall be tested for permanent set and the results shall not differ by more than 25 per cent of the percentage values obtained. In case of greater variation than specified, additional specimens shall be tested. The final value shall be the average of the check tests. Results on specimens found to be imperfect shall be discarded and retests shall be made.

PROCEDURE

13. (*a*) *Tensile Strength and Ultimate Elongation.*—The test specimen shall be placed in the grips using care to adjust them symmetrically in order that the tension shall be distributed uniformly over the cross-section. The grips shall be separated at the specified rate of speed until rupture takes place and during separation, the distance between the gage marks on the specimen shall be noted continuously so that at the instant of rupture the distance is known within 0.1 in. This value shall be recorded together with the original distance between the gage marks from which data the ultimate elongation may be calculated. After rupture of the specimen, the breaking load in pounds shall be noted from the dial or scale and recorded together with the original minimum width and thickness of the specimen so that the tensile strength may be calculated.

(*b*) *Stress-Strain Properties.*—The procedure shall be the same as in Paragraph (*a*) except that the load and extension shall be recorded at equal increments of 100 per cent elongation as well as at rupture. Use of an autographic or spark recorder for registering observed loads is recommended. A tension testing machine equipped with a dynamometer head of the compensating type is convenient in eliminating calculations and its use is permitted in stress-strain tests.

(*c*) *Permanent Set.*—The test specimen shall be placed in the grips of the test apparatus as in Paragraph (*a*) and the grips separated at the machine speed or by hand at a uniform rate of speed such as to require approximately 15 sec. to reach the specified elongation. The specimen shall be held in this stretched position for 10 min., released immediately but without being allowed to snap back and allowed to rest for 10 min. The distance between the gage marks shall then be measured to the nearest 0.01 in. and recorded together with the original distance between the marks. The difference is the measure of the permanent set. If no specified elongation is given for the permanent set determination, the test specimen shall be stretched an amount equal to three-fourths of the ultimate elongation determined as in Paragraph (*a*).

REPORT

Calculation of Results

14. (*a*) *Tensile Strength* shall be calculated by dividing the breaking load in pounds by the original area of the cross-section of the test specimen in square inches and shall be expressed in pounds per square inch.

(*b*) *Ultimate elongation* shall be calculated by subtracting the original distance between gage marks in inches from the total distance between the marks at the time of rupture as measured in Section 13 (*a*) and expressing this difference as a percentage of the original distance, as follows:

$$\text{Ultimate Elongation, per cent} = \frac{(\text{Distance at Break} - \text{Original Distance})}{\text{Original Distance}} \times 100$$

(*c*) *Stress-Strain Properties.*—Tensile stresses shall be calculated as in the case of tensile strength except that the observed loads shall be used in place of the breaking load. Elongation or strain shall be calculated as in the case of ultimate elongation except that the observed distance between the gage marks at each recorded extension shall be used in place of the distance at break.

(*d*) *Permanent Set* shall be calculated as a percentage of the original distance between the gage marks by taking the difference between the gage mark distance after the rest period and the original distance as described in Section 13 (*c*), multiplying by 100 and dividing the product by the original distance.

Report

15. The report shall include the following:

(*a*) The results calculated in accordance with Section 14.
(*b*) All observed and recorded data on which the calculations are based.
(*c*) The date of vulcanization of the rubber, if known.
(*d*) The date of test.
(*e*) The temperature of the test room.
(*f*) The type of test machine used.
(*g*) The dimensions of the die used in preparing the test specimens.

TENTATIVE METHODS OF TEST
FOR
ACCELERATED AGING OF VULCANIZED RUBBER[1]

A.S.T.M. Designation: D 428 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1935; REVISED, 1936.

Scope

1. (*a*) These methods are intended for use in estimating the relative resistance of vulcanized rubber compounds to age deterioration. No direct correlation between these accelerated tests and natural life of rubber is given nor implied. Since the rate at which deterioration proceeds during the normal life of rubber varies widely depending on conditions of exposure to heat, light and air and on the composition and state of cure of the rubber, these accelerated tests are comparative only and must be evaluated against the performance of rubber compounds of which both the natural and accelerated aging characteristics are known.

(*b*) Except as otherwise specified in these methods, the requirements of the Tentative Methods of Physical Testing of Rubber Products (General Requirements) (A.S.T.M. Designation: D 15 - 35 T) of the American Society for Testing Materials[2] shall be complied with and are made a part of these methods.

(*c*) In case of conflict between the provisions of these methods and those of detailed specifications or methods of test for a particular material, the latter shall take precedence.

Types of Tests

2. (*a*) Aging tests of rubber consist of subjecting test specimens having previously determined physical properties to controlled deteriorating influences for known periods after which the physical properties are again measured and the changes noted. In these methods, two types of test are given which differ in that the specimens are exposed at an elevated temperature to different conditions of oxidizing atmospheres. Neither type includes exposure to light. They are designated as (*1*) air-oven aging test, and (*2*) oxygen-pressure-chamber aging test.

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-11 on Rubber Products.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1153 (1935); also 1936 Book of A.S.T.M. Tentative Standards, p. 1103.

(*b*) In both types of aging tests, the physical properties used to measure the deterioration of the rubber in addition to visual and manual inspection, are tensile strength, ultimate elongation and stress-strain relationship. Except as otherwise specified in these methods, the determination of these properties before and after aging shall be carried out in accordance with the Tentative Methods of Tension Testing of Vulcanized Rubber (A.S.T.M. Designation: D 412 – 36 T) of the American Society for Testing Materials.[1]

Air Oven

3. The air oven shall conform to the following requirements:

(*a*) The interior size shall be as follows or of an equivalent volume:

Interior size of air oven	Minimum	12 by 12 by 12 in.
	Maximum	36 by 36 by 48 in.

(*b*) Provision shall be made for suspending specimens vertically without touching each other or the sides of the aging chamber.

(*c*) The operating temperature shall be 70 C. ±1 C.

(*d*) The temperature variation in various parts of the oven shall not exceed 2 C.

(*e*) The heating medium for the aging chamber shall be air circulated within it at atmospheric pressure.

(*f*) The source of heat is optional but shall be located in the air supply outside of the aging chamber proper.

(*g*) A recording thermometer located in the upper central portion of the chamber near the center of the aging specimens shall be provided to record the actual aging temperature.

(*h*) Automatic temperature control by means of thermostatic regulation shall be used.

(*i*) The following special precautions shall be taken in order that accurate, uniform heating is obtained in all parts of the aging chamber:

(*1*) The heated air shall be thoroughly circulated in the oven by means of mechanical agitation. When a motor-driven fan is used, the air must not come in contact with the fan motor brush discharge because of danger of ozone formation.

(*2*) Baffles shall be used as required to prevent local overheating and dead spots.

(*3*) The thermostatic control device shall be so located as to give accurate temperature control of the heating medium. The preferred location is adjacent to the recording thermometer.

(*4*) An actual check shall be made by means of maximum reading thermometers placed in various parts of the oven to verify the uniformity of the heating.

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[1] See p. 1105.

Oxygen Pressure Chamber Equipment

4. The oxygen pressure chamber shall consist of a metal vessel designed to retain an internal atmosphere of oxygen gas under pressure with provisions for placing rubber specimens within it and subjecting the whole to controlled uniform temperature. Two suggested designs which are suitable are shown in Figs. 1 and 2. The equipment shall conform to the following requirements:

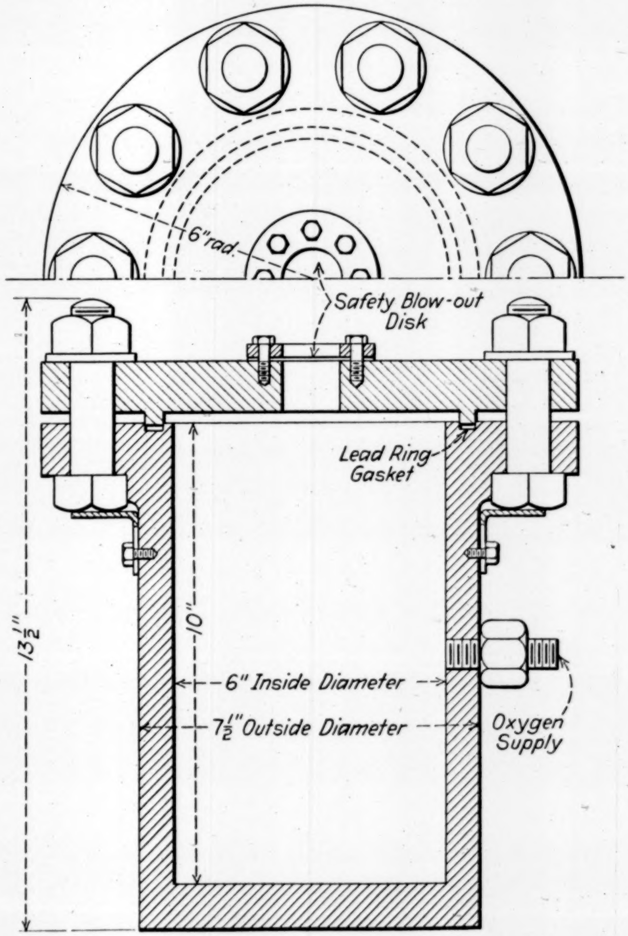
6" rad.
Safety Blow-out Disk
Lead Ring Gasket
13½"
10"
6" Inside Diameter
7½" Outside Diameter
Oxygen Supply

FIG. 1.—Oxygen Pressure Aging Chamber, Non-Jacketed for Water or Air Bath.

(*a*) The size of the chamber shall be optional but shall be such that the specimens may be suspended therein vertically without undue crowding and without touching each other or the sides of the chamber.

(*b*) The operating temperature shall be 70 C. ± 1 C. determined by measuring the temperature of the heating medium which shall be considered the same as that of the pressure chamber.

(*c*) The source of heat is optional but necessarily must be located outside of the aging chamber proper.

(*d*) The heating medium is optional but water is preferred because of more rapid heat transfer. When the design shown in Fig. 1 is used, it is convenient to employ for the heating a calorimeter water bath in which the entire chamber is immersed. If air is used, precautions similar to those specified in Section 3 (*i*) for the air oven must be observed to insure uniform heating.

(*e*) Automatic temperature control of the heating medium by means of thermostatic regulation shall be used.

(*f*) A recording thermometer located in the heating medium shall be provided to record the actual temperature. Preferably, the thermometer bulb should be close to the wall of the pressure chamber but not touching it.

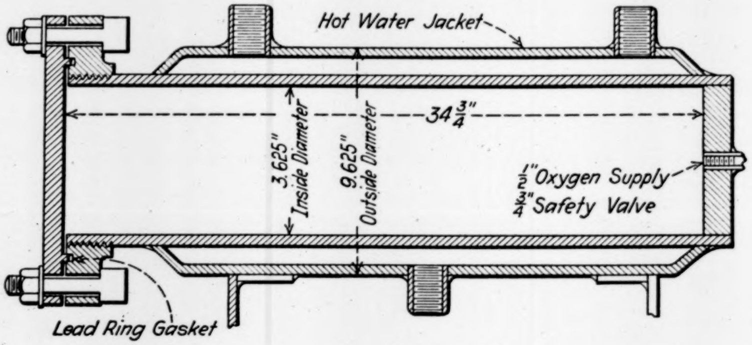

FIG. 2.—Oxygen Pressure Aging Chamber, Hot-Water Jacketed.

(*g*) Positive, rapid and complete circulation of the heating medium shall be maintained so as to assure accurate, uniform heating.

(*h*) The pressure of oxygen supplied to the aging chamber shall be 300 ± 10 lb. per sq. in. as measured by a calibrated pressure gage.

(*i*) The pressure chamber shall be equipped with a reliable safety valve set for release at 500 lb. per sq. in. pressure.

NOTE: *Caution.*—Adequate safety provisions are important when heating oxidizable organic materials in oxygen since the rate of reaction may become very rapid in some cases, particularly if large surface area is exposed, and very high pressures may be developed.

Shape of Test Specimens

5. Dumb-bell shaped test specimens, prepared as described in the Tentative Methods of Tension Testing of Vulcanized Rubber (A.S.T.M. Designation: D 412 – 36 T) of the American Society for Testing Materials[1] shall be considered standard. Their form shall be such that no mechanical, chemical or heat treatment will be required after aging. If buffing is necessary, it shall be performed prior to the aging cycle.

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[1] See p. 1105.

Size of Test Specimens

6. The dimensions of the test specimens for calculating the physical properties shall be measured prior to starting the aging cycle. Care shall be taken that the material used for marking the gage lines on the specimens is not detrimental to the rubber during aging exposure causing the specimens to break at the marks prematurely during test. Only specimens of similar dimensions having approximately the same exposed areas may be compared with each other.

Number of Test Specimens

7. (*a*) At least three specimens shall be used to determine the average original physical properties of the rubber and also three or more specimens of the same material for each aging interval of the test.

(*b*) When minimum requirements are established, one test shall be made for tensile strength and elongation. If the results are below the specified requirements, two additional specimens shall be prepared from the original sample and tested. Should the results of either of these tests be below the specified requirements, the sample shall be considered to have failed to meet the specifications.

Tests of Unaged Specimens

8. (*a*) The stress-strain properties or tensile strength and ultimate elongation of the original unaged specimens shall be determined within 24 hr. of the start of the aging period. Results on specimens which break outside of the straight reduced section or which are found to be imperfect shall be discarded. Retests shall be made of original unaged specimens so discarded.

(*b*) When rubber compounds are to be tested for the purpose of determining compliance with a specification, it shall be permissible to test the original properties required in Paragraph (*a*) simultaneously with the determination of the values after the first aging period even though the elapsed time exceeds 24 hr.

Accelerated Aging of Specimens

9. The specimens for aging shall be placed in the aging chamber after it has been preheated to the operating temperature. It is recommended that not more than 2.0 g. of actual rubber or oxidizable substance per cubic inch of capacity be placed in the chamber. Simultaneous aging of a mixed group of different compounds shall be avoided if possible. For instance, high-sulfur compounds should not be aged with low-sulfur compounds and those containing anti-oxidants should not be aged with those having no age-resistors. Some migration is known to occur. When starting an oxygen-pressure aging test, the air shall be flushed out by releasing the oxygen pressure and refilling and the chamber shall be checked to make certain the apparatus does not leak.

(*b*) The aging interval shall start at the time the specimens are placed in the heated chamber and shall continue for a measured time interval. The selection of suitable intervals of aging will depend on the rate of deterioration of the particular material being tested. Air-oven tests are commonly extended over intervals of days and oxygen-pressure-chamber tests for periods of hours. Intervals frequently used are as follows:

Air-oven tests	2, 4, 7 and 14 days
Oxygen-pressure-chamber tests	24, 48, 72 and 96 hr.

(*c*) Such aging intervals shall be used that the deterioration will not be so great as to prevent determination of the final physical properties. In experimental work, it is desirable to use a range of periods, while for routine tests of known materials fewer intervals may be employed.

(*d*) At the termination of the aging interval, the specimens shall be removed from the aging chamber, cooled to room temperature on a flat surface and allowed to rest not less than 16 hr. nor more than 48 hr. before determination of the physical properties. In relieving the pressure from the oxygen pressure chamber preparatory to removing the aged specimens, it is essential that the release be slow and uniform, requiring at least 2 min. so as to avoid possible formation of porosity in the specimen.

Tests of Aged Specimens

10. The tensile strength and ultimate elongation or the stress-strain properties of the specimens aged for different intervals shall be determined as the intervals terminate in the progress of aging, disregarding the fact that more specimens may still be aging. In determining the physical properties after aging, the final values shall be the average of results from at least two specimens including that one giving the highest value for ultimate tensile strength and any which check that value within 10 per cent. Results of tests of all other specimens shall be discarded. In the event that discarding of aged specimens both from faulty breaks and failure to check does not leave two satisfactory determinations, additional specimens shall be aged and tested until two or more check results from properly broken specimens are obtained. After completion of the tests, the broken, aged specimens shall be examined visually and manually and their condition noted.

Expression of Results

11. The results of the aging test shall be expressed in the form of percentage of deterioration in each physical property (tensile strength, ultimate elongation or tensile stress), calculated as follows:

$$\text{Percentage of Deterioration} = \frac{(\text{Original Value} - \text{Value after Aging}) \times 100}{\text{Original Value}}$$

Report

12. The report shall include the following:

(*a*) The results calculated in accordance with Section 11.

(*b*) All observed and recorded data on which the calculations are based.

(*c*) Type of aging test.

(*d*) The aging interval.

(*e*) The duration, temperature and date of vulcanization of the rubber, if known.

(*f*) Dates of original and final determinations of physical properties.

(*g*) Dimensions of test specimens.

TENTATIVE METHODS OF TEST
FOR
ADHESION OF VULCANIZED RUBBER (FRICTION TEST)[1]

A.S.T.M. Designation: D 413 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1935; Revised, 1936.

Scope

1. (*a*) These methods of test are intended to be used for measuring the strength of adhesion between plies of fabric bonded with rubber or the adhesion of the rubber layer in articles made from rubber attached to another material. They are applicable only when the adhered surfaces are approximately plane or uniformly circular as in belting, hose, tire carcasses, or rubber-covered sheet metal. When the adhered surfaces contain sharp bends, angles or other gross irregularities which cannot be avoided in preparing test specimens, special methods must be employed for evaluating adhesion.

(*b*) Two general methods of test are given. The first involves application of force by means of weights and is called the "Dead-Weight Method." The second employs a tension testing machine and is known as the "Machine Method."

(*c*) As covered by these methods, an adhesion test shall be understood to consist of applying to a test specimen under specified conditions, a measured force sufficient to strip from the specimen at a measured rate a layer of moderate thickness with separation at the adhered surfaces. The numerical value of the adhesion may therefore be expressed as (*1*) average force required to cause separation at a definite rate, or (*2*) average rate of separation caused by a known or specified force. In the machine method, the rate of separation is fixed and the adhesion value must be expressed in terms of the measured tension. With the dead-weight test, either method can be used but the latter is preferable and will be here employed.

(*d*) Except as may be otherwise specified in these methods, the requirements of the Tentative Methods of Physical Testing of Rubber Products (General Requirements) (A.S.T.M. Designation: D 15 – 35 T) of the

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-11 on Rubber Products.

American Society for Testing Materials[1] shall be complied with and are made a part of these methods.

(*e*) In case of conflict between the provisions of these methods and those of detailed specifications or methods of test for a particular material, the latter shall take precedence.

TEST SPECIMENS

Size and Shape

2. (*a*) Test specimens shall conform to one of two types as follows:

Strip Specimens.—Plane strips having a width of 1.00 in. ± 0.01 in., and a minimum length such as to permit separation over sufficient distance to indicate the adhesion value.

Ring Specimens.—Closed rings having a width of 1.00 in. ± 0.01 in. and maximum internal diameter of 4 in.

(*b*) Test specimens may vary in thickness according to the construction of the article being tested but the portion from which a ply or layer is being separated shall not be of less thickness than such ply or layer and in no case shall the thickness of the latter exceed $\frac{1}{4}$ in. If necessary, in order to comply with this requirement, slicing or buffing may be employed.

(*c*) Curved specimens for test in strip form shall have curvature only in the length dimension of the test specimen.

Cutting of Specimens

3. (*a*) If practicable, the test specimens shall be cut from the article to be tested in such manner that the adhered parts shall have the same one-inch width. When necessary or when so specified, only the layer which is to be separated by application of load may be cut to the one-inch width but in such case, the portions of that layer remaining outside of the test width shall be removed from the other layers to avoid edge constriction during separation.

(*b*) Cutting of test specimens shall be done using a sharp tool which will leave clean edges. Ring specimens as from hose samples are conveniently prepared by mounting the material on a smooth, close-fitting, slightly tapered wooden mandrel which can be rotated in a lathe and cutting 1-in. sections with a sharp-pointed wet knife forced gradually through the material.

(*c*) Rings having internal diameters over 4 in. shall be cut through and opened to form strip specimens.

DEAD-WEIGHT METHOD

Apparatus

4. The apparatus required for the adhesion test by the dead-weight method consists of a supporting frame, testing clamps, mandrels, calibrated

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1153 (1935); also 1936 Book of A.S.T.M. Tentative Standards, p. 1103

weights and weight carriers. The supporting frame shall be of such design that clamps for ring specimens may be hung on it vertically and that mandrels for strip specimens may be supported on it horizontally. The frame must have sufficient height to permit weights to be suspended from the test specimens by means of clamps and to hang freely during the progress of the test. Provision also shall be made to support the mandrels so that they may revolve freely with minimum friction. Suitable apparatus is shown in Figs. 1 and 2.

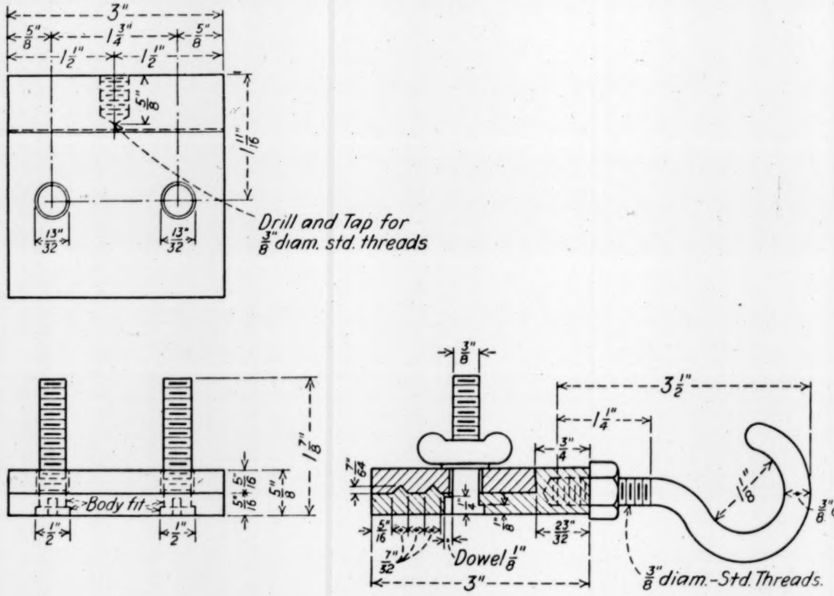

FIG. 1.—Clamp for Adhesion Test.

Procedure

5. (*a*) *Testing Strip Specimens.*—The parts to be tested shall be separated by hand at one end of the strip specimen a sufficient distance to permit attaching the jaws of the testing clamp. The strip shall be suspended from the supporting frame by the separated end, all separate parts of which except the one under test, shall be held in the jaws of the testing clamp. A minimum weight sufficient to maintain the strip specimen in approximately a vertical position shall be attached to the lower end of the test specimen, or the specimen may be held against a vertical plate in such a manner as to keep the specimen in approximately a vertical position during test. A specified or known weight shall be applied by means of a clamp and weight carrier to the layer of which the adhesion is to be determined. The weight of the clamp and carrier shall be included in the total weight causing separation. Suitable provision shall be made for releasing the weight

slowly without jerking and in such a manner that the separating layer will be stripped from the specimen approximately at an angle of 180 deg.

(*b*) *Testing Ring Specimens.*—The ring specimen shall be placed snugly on a mandrel having an outside diameter substantially the same as the internal diameter of the ring. The parts to be tested shall be separated sufficiently by hand to permit attaching the jaws of the testing clamp. With the mandrel resting on the supporting frame, a known or specified weight shall be applied by means of the clamp and a weight carrier to the layer of which the adhesion is to be tested. The weight of the clamp and carrier shall be included in the total weight causing separation. Suitable provision shall be made for releasing the weight slowly without jerking and in such a manner that the separating layer will be stripped from the specimen approximately at an angle of 90 deg.

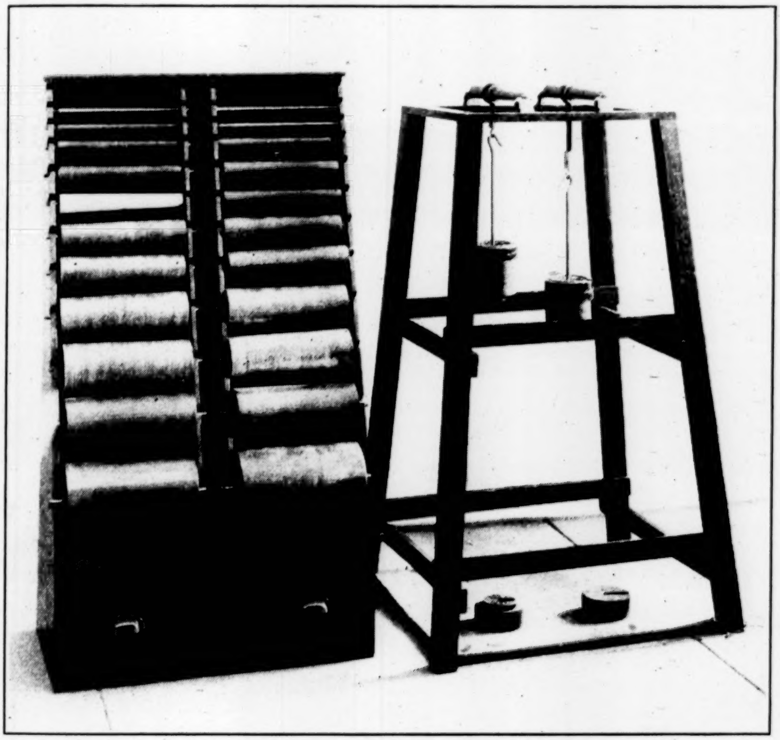

FIG. 2.—Mandrels and Frame for Dead-Weight Adhesion Test.

(*c*) *Rate of Separation.*—The rate of separation shall be determined by observing the duration of the test with a stop-watch or a watch having a second hand and by measuring, after the weight has been removed, the length stripped between marks placed at the beginning and end of the test on the other portion than that stripped.

MACHINE METHOD

Apparatus

6. Adhesion tests by the machine method shall be made on a power-driven apparatus, preferably of the inclination balance or pendulum type, although a spring-balance apparatus may be used. The machine shall fulfill the requirements of the following Paragraphs (*a*) to (*g*):

(*a*) The applied tension as measured and recorded shall be accurate within ± 1 per cent.

(*b*) Strip specimens shall be held in the testing machine by grips which clamp firmly and prevent slipping at all times during the test. For ring specimens the grip attached to the recording head of the machine shall be replaced with a freely rotating mandrel having an outside diameter substantially the same as the inside diameter of the ring which is placed on it. The mandrel shall be mounted in such a way that its axis of rotation will be in the plane of the ply being separated from the ring and that the applied force will be normal to the tangent of the ring circumference at the line of separation.

(*c*) The grips which hold the specimen in the testing machine shall clamp firmly and prevent slipping at all times during the test.

(*d*) The rate of travel of the power-actuated grip shall be 2 in. per min. for strip specimens and 1 in. per min. for ring specimens uniformly throughout the test giving a rate of separation of 1 in. per min. in both cases.

(*e*) The machine shall be operated without any device for maintaining maximum load indication. In pendulum type machines, the weight lever shall swing as a free pendulum without engagement of pawls.

(*f*) The machine shall be autographic giving a chart having rate of separation as one axis and applied tension as the other axis of coordinates.

(*g*) The machine shall be of such capacity that the maximum applied tension during adhesion test shall not exceed 85 per cent nor be less than 15 per cent of the rated capacity.

Procedure

7. (*a*) *Strip Specimens.*—The parts to be tested shall be separated by hand at one end of the test specimen sufficiently to permit clamping in the grips of the machine. The separated end of the specimen with all separate parts except the one under test securely gripped shall be attached to the recording head by means of a clamp using care to adjust it symmetrically in order that the tension shall be distributed uniformly. Provision shall be made to maintain the strip during test approximately in the plane of the clamps. This may be done either by attaching the minimum weight required to the free end of the specimen or by holding the specimen against a plate attached to the stationary clamp but, in either case, the added weight shall be taken into account in determining the load

causing separation. The layer of which the adhesion is to be tested shall be gripped symmetrically and firmly without twisting in the power-actuated clamp. The autographic mechanism and chart shall be adjusted to zero and the machine started. The separating layer shall be stripped from the specimen approximately at an angle of 180 deg. and the separation continued for a sufficient distance to indicate the adhesion value.

(*b*) *Ring Specimens.*—With ring specimens the layer of which the adhesion is to be tested shall be separated from the specimen by hand sufficiently to permit attaching the power-actuated clamp of the machine. The specimen shall be placed snugly on the test mandrel as described in Section 6 (*c*). With the mandrel attached to the recording head of the machine and the separated layer gripped symmetrically and firmly without twisting in the power-actuated clamp, the autographic mechanism and chart shall be adjusted to zero and the machine started. The separating layer shall be stripped from the specimen approximately at an angle of 90 deg. to the tangent of the specimen surface and the separation continued for a sufficient distance to indicate the adhesion value. During the test, the mandrel shall rotate freely so as to maintain the line of separation at all times approximately in the same position.

PRECAUTIONS AND CHECK TESTS

Tearing

8. If, during a test, one of the parts begins to tear, instead of separating from the other part of the specimen, the material being torn shall be cut with a knife up to the surface of contact between the two parts and the test started again. If one of the parts repeatedly tears, instead of separating from the other part, a satisfactory result may be secured in the dead-weight method by reducing the amount of the weight used if this is permitted. In case of repeated tearing when using the machine method, the average load at which tearing occurs shall be taken as the result of the test. In cases of tearing, the results shall be so designated.

Effect of Temperature

9. The results of this test are affected by temperature. Elevating the temperature causes a faster rate of stripping under a given load. The temperature during test shall therefore be between 70 and 90 F. (21 and 32 C.) and the actual temperature shall be recorded.

Interpretation of Results

10. (*a*) In the dead-weight method, no stripping is started unless a certain weight is used. Small increments in weight do not progressively cause proportional increases in rate of separation. With increasing weight the rate increases slowly at first and finally very rapidly. Rate of separation must therefore be interpreted carefully. A specimen required to

separate not more than 1 in. per min. under 20-lb. weight might be regarded as very inferior if the test result was 5 in. per min. The same specimen might not strip at all under 15-lb. weight and might meet the requirement with 18-lb. weight.

(*b*) The true adhesion value is not determined in case the specimens repeatedly tear. The test, however, indicates that the strength of adhesion exceeds the strength of the material and that the adhesion value is not less than the result obtained.

(*c*) Adhesion values may differ between different plies of the same article of plied construction and also at different points along the same ply. The adhesion value of one ply to another is taken as the average result of the test over a reasonable distance of separation. When possible, a distance of separation of at least 4 in. shall be used.

Check Tests

11. The adhesion value shall be based on the result of a single test. In case of testing to meet a specified value, one check test shall be made if the average strength as determined by the machine method fails by less than one-half pound to meet the specifications or if the rate of separation determined by the dead-weight method exceeds the specified rate by not more than ten per cent. The check test result shall be considered final.

REPORT

Expression of Results

12. (*a*) With the dead-weight method, the value of the adhesion shall be reported as inches of separation per minute per inch of width under a stated weight.

(*b*) With the machine method, the autographic chart constitutes the report but the value of the adhesion shall be determined by drawing on the chart the best average line between the maximum and minimum load values. The load so indicated expressed in pounds per inch width for separation at 1 in. per min. shall be reported as the adhesion value.

Report

13. The report shall include the following:

(*a*) Results of the adhesion test determined in accordance with Section 12.

(*b*) All observations and recorded data on which the results are based.

(*c*) The date of manufacture or vulcanization of rubber, if known.

(*d*) The date of test.

(*e*) Statement of method used.

(*f*) Temperature of test room.

(*g*) Dimensions of test specimen.

TENTATIVE METHOD OF TEST
FOR
ADHESION OF VULCANIZED RUBBER TO METAL[1]

A.S.T.M. Designation: D 429 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1935; Revised, 1936.

Scope

1. (*a*) This method is intended to be used for testing the strength of adhesion of rubber to metal in articles where a rubber part is assembled between two parallel metal plates.

(*b*) The method is designed primarily to apply to specimens prepared in a laboratory under standardized conditions such as may be used to provide data for development and control of rubber compounds and methods of manufacture. With slight modifications as indicated, it may also be used for obtaining comparative adhesion tests of production parts whenever the design permits preparation of suitable test specimens. It is applicable in the case of many automotive parts in which rubber is used for the purpose of damping vibration.

(*c*) The method does not cover the testing of adhesion of rubber to metal when the part has metal on one side of the rubber only. For such cases reference should be made to the Tentative Methods of Test for Adhesion of Vulcanized Rubber (Friction Test) (A.S.T.M. Designation: D 413 - 36 T) of the American Society for Testing Materials.[2]

(*d*) Except as otherwise specified in this method, the requirements of the Tentative Methods of Physical Testing of Rubber Products (General Requirements) (A.S.T.M. Designation: D 15 - 35 T) of the American Society of Testing Materials[3] shall be complied with and are made a part of this method.

Testing Machine

2. A tension testing machine conforming to the requirements of the Standard Methods of Verification of Testing Machines (A.S.T.M. Desig-

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[1] **Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M Committee D-11 on Rubber Products.**

[2] See p. 1120.

[3] *Proceedings,* Am. Soc. Testing Mats., Vol. 35, Part I, p. 1153 (1935); also 1936 Book of A.S.T.M. Tentative Standards, p. 1103.

nation: E 4) of the American Society for Testing Materials[1] shall be used for measuring the strength of adhesion. The moving head of the machine shall travel at the rate of 1 in. per min. The machine shall be provided with a recording device to give the total pull in pounds at the conclusion of the test. A machine of not more than 10,000-lb. capacity will be found suitable in most cases.

Grips

3. The fixtures for holding the specimen in the testing machine will depend on the type of specimen but in all cases shall be provided with ball seats to permit proper centering of the load during test. Specially molded laboratory specimens shall be attached by means of threaded studs on the metal parts as shown in Fig. 1, but with specimens cut from production parts the clamp illustrated in Fig. 4 shall be used.

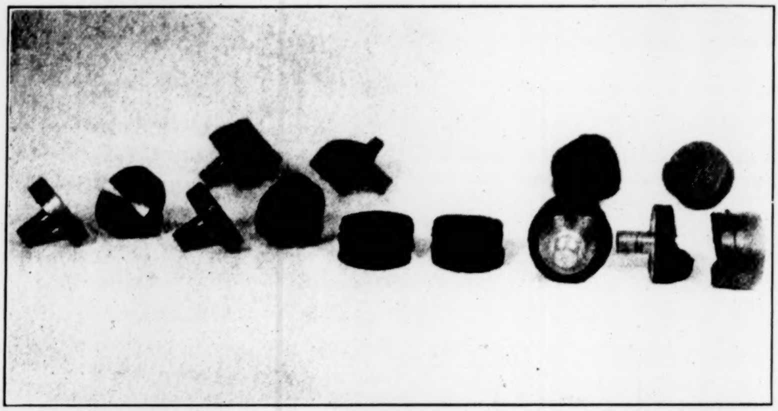

FIG. 1.—Views of Test Specimen Showing Individual Metal Parts and Rubber Cylinders.

Standard Test Specimens

4. The standard test specimen shall consist of a cylinder of rubber 0.500 in. ± 0.005 in. in thickness and 1.579 in. ± 0.001 in. in diameter having its circular ends attached to the faces of two metal plates each 0.375 in. in thickness and of the same diameter as the rubber cylinder. The metal plates shall have smooth flat faces which shall be parallel in the finished specimen. The cylindrical shape is used to eliminate sharp corners and to give uniform distribution of the pulling force. The specified diameter which provides a cross-sectional area of 2 sq. in. and the $\frac{1}{2}$ in. thickness of rubber have been selected to provide as large a volume of rubber as advisable without introducing possibility of variations in cure and elongation which would affect the total pull required during test to cause complete separation of the rubber from the metal.

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[1] 1936 Book of A.S.T.M. Standards, Parts I and II, pp. 849 and 1417, respectively.

Laboratory Preparation of Standard Test Specimens

5. For laboratory preparation of test specimens to be used for development and control purposes, the procedure described in the following Paragraphs (*a*) to (*e*) shall be used:

(*a*) Circular metal parts of standard dimensions shall be machined from rolled bar steel, S.A.E. No. 1020, each having on the back face a round stud $\frac{1}{2}$ in. in diameter and $\frac{3}{4}$ in. in length, threaded with 20 threads per inch as shown in Fig. 3. The stud is used for attaching the test piece to the loading fixture in the testing machine. The smoothly machined test faces of the metals shall be brass plated or prepared in accordance with any method for securing adhesion which may be under investigation.

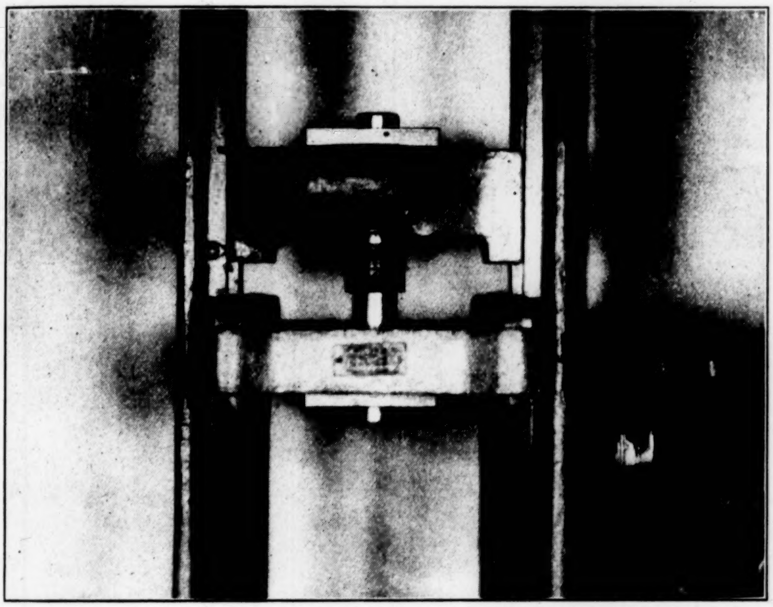

FIG. 2.—Adhesion Test Specimen Attached in Testing Machine.

(*b*) Unvulcanized rubber pieces shall be cut to dimensions of $1\frac{3}{8}$ in. in diameter and $\frac{3}{4}$ in. in thickness so as to give maximum pressure of the rubber against the metal surfaces during vulcanization (see Fig. 1). The surfaces to be adhered shall be washed or treated in accordance with the method being investigated.

(*c*) The metal parts and rubber pieces shall then be assembled for vulcanization in the mold shown in Fig. 3. The method of assembly is illustrated in Fig. 1. The mold is so constructed that there is obtained after vulcanization approximately 0.0015 in. of rubber over the edge of the metal to eliminate tearing of the rubber during test from the sharp edge of the metal. Prior to vulcanization great care shall be taken to keep the surfaces to be adhered clean and free from dust, moisture or other foreign material. The surfaces shall not be touched with the hands.

(*d*) Vulcanization shall be carried out by heating the mold for a definite time at a controlled temperature in a hydraulic vulcanizing press. The time and temperature of cure shall be chosen according to the rubber compound used. At the conclusion of the cure, care shall be taken in removing the specimens from the mold to avoid subjecting the adhered surfaces to stress before the specimens have cooled.

(*e*) After vulcanization the specimens shall be kept at room temperature at least 24 hr. before being tested.

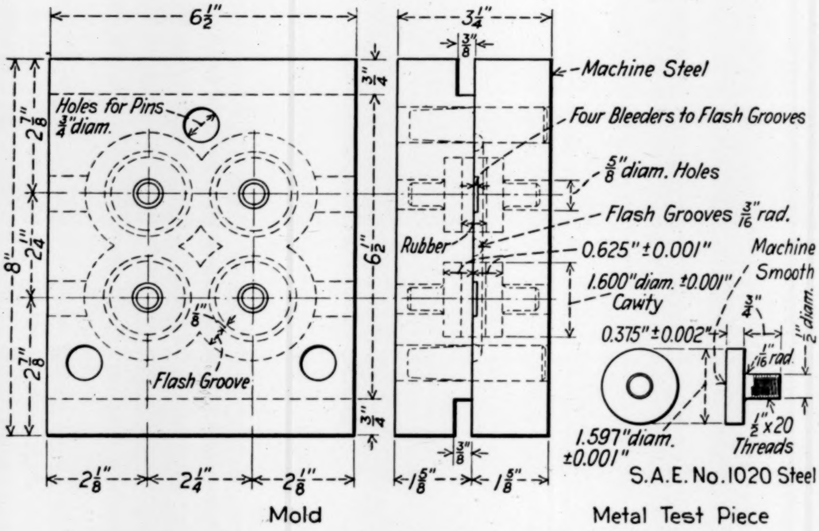
6½"
3¼"
3/8"
Machine Steel
Four Bleeders to Flash Grooves
Holes for Pins ¾" diam.
2⅞"
2¼"
8"
2⅞"
3/4"
6½"
3/4"
5/8" diam. Holes
Flash Grooves 3/16" rad.
Rubber
0.625" ±0.001"
Machine Smooth
1.600" diam. ±0.001" Cavity
3/4"
1/2" diam.
0.375" ±0.002"
1/16" rad.
1/8"
Flash Groove
1.597" diam. ±0.001"
1/2" x 20 Threads
S.A.E. No. 1020 Steel
3/8"
2⅛"
2¼"
2⅛"
1⅝"
1⅝"
Mold
Metal Test Piece

FIG. 3.—Detailed Drawing of Mold for Adhesion Test Pieces.

Preparation of Specimens from Production Parts

6. (*a*) For comparative tests of adhesion in production parts it is necessary to select a portion of the part such that a specimen consisting of a rubber piece sandwiched between two parallel plates of metal may be cut. The specimen shall be hollow-milled out of the production part and the piece shall be finished either by turning or grinding down to size in such a manner that the surfaces of the rubber and metal shall be free from imperfections which would have any tendency to start a tear in the rubber part during the application of tension while testing.

(*b*) In routine production testing, it is sometimes necessary to test specimens of different size and shape than those specified as standard. In such cases, the method of preparation shall be similar to that given in

Paragraph (*a*) but the test results secured shall not be compared with those obtained using the standard specimen.

Testing Procedure

7. The vulcanized standard test specimen or the specimen cut from a production part shall be mounted in the testing machine, using care in centering and adjustment so that the tension shall be uniformly distributed. A steady tension load shall then be applied at the specified machine speed until the rubber either separates from the metal surface or ruptures. The total load at the time of failure shall be recorded. In case of rupture in the rubber, the strength of the adhesion bond is obviously not measured, but is shown to be greater than the strength of the rubber itself. Notation to this effect shall be made on the test report. It is usual, however, when high-grade rubber compounds are used, for the failure to occur at the rubber-metal interface and the maximum applied pull then truly evaluates the strength of adhesion.

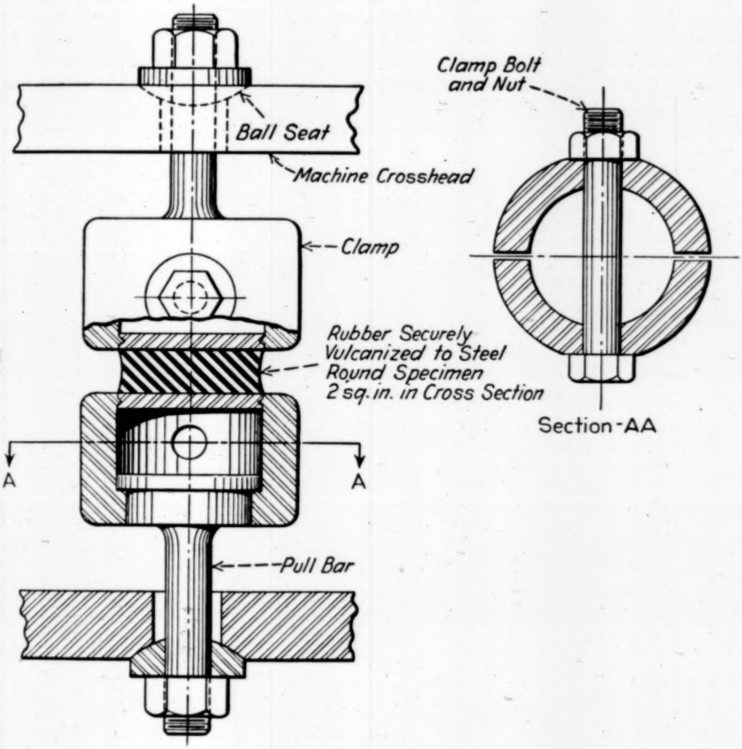
Clamp Bolt and Nut
Ball Seat
Machine Crosshead
Clamp
Rubber Securely Vulcanized to Steel Round Specimen 2 sq. in. in Cross Section
Section-AA
A
A
Pull Bar

FIG. 4.—Method of Testing Adhesion When Sample Section Is Taken from Production Parts.

Check Tests

8. Two tests shall be made and the average value taken if the results check within 100 lb. per sq. in. In the event that the two results fail to check within 100 lb. per sq. in., three additional specimens shall be tested and the average of all five tests shall be reported.

Calculation of Results

9. The adhesion value shall be expressed in pounds per square inch and shall be calculated by dividing the tension load causing failure by the original area of the adhered surface which separates. With the standard specimen, the value is the load at failure divided by two. In case of rupture of the rubber, the value reported is the load at failure divided by the original cross-sectional area of the specimen.

Report

10. The report shall include the following:

(*a*) The result calculated in accordance with Section 9.

(*b*) All observed and recorded data.

(*c*) Notation of the type of separation and statement of whether the results show true adhesion values or strength of the rubber.

(*d*) A description of the specimen including statement of method of securing adhesion if known and notation of whether the specimen was molded in the laboratory or prepared from a production part.

(*e*) Dimensions of the test specimen. Comparisons may only be made between specimens of the same size and shape.

(*f*) Date of manufacture or vulcanization, if known.

(*g*) Time and temperature of vulcanization, if known.

(*h*) Temperature of test room.

(*i*) Date of test.

TENTATIVE METHODS OF TEST
FOR
COMPRESSION SET OF VULCANIZED RUBBER[1]

A.S.T.M. Designation: D 395 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1935; REVISED, 1936.

Scope

1. These methods are designed for testing vulcanized rubber parts which are to be assembled in such a manner that the rubber will be subjected to compressive stresses or shear. They are applicable particularly to the rubber used in machinery mountings and vibration dampers.

Compression Set

2. For the purposes of these tests, compression set of rubber shall be considered as the residual decrease in thickness, expressed as the percentage of the original thickness, of a test specimen measured 30 min. after removal from a suitable loading device in which the specimen had been subjected for a definite time to compressive deformation under specified conditions of load application and temperature.

Types of Tests

3. (*a*) Compression set tests are intended to measure the ability of rubber compounds to retain elastic properties during prolonged action of compressive stresses. The actual stressing in service may involve the maintenance of a definite deflection, the constant application of a known load or the rapidly repeated deformation and recovery resulting from intermittent compressive forces. Though the latter dynamic stressing, like the others, produces compression set, its effects as a whole are more closely simulated by compression flexing or hysteresis tests. Therefore, compression set tests are considered to be only those involving static loading.

(*b*) These methods cover the following two test procedures using different types of load application:

Method A.—Test for compression set of vulcanized rubber under constant load.

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-11 on Rubber Products.

Method B.—Test for compression set of vulcanized rubber under constant deflection.

(*c*) The choice of method is optional but consideration should be given to the nature of the service for which correlation of test results may be sought. Notation shall be made in each test of the method actually used.

4. In case of conflict between the provisions of these methods and those of detailed specifications or methods of test for a particular material, Method B shall take precedence.

Compression Device

5. The compression devices as specified in Section 11 for Method A and in Section 20 for Method B shall be used.

Plates

6. The plates between which the test specimen is compressed shall be made of steel of sufficient thickness to withstand the compressive stresses without bending. The surfaces against which the specimen is held shall have a highly polished chromium plate finish and shall be thoroughly cleaned and wiped dry before each test.

Oven

7. Any well-designed, uniformly heated standard dry-air oven of sufficient size to hold the compression device may be used for this test. The oven shall be provided with proper temperature control to maintain the specified temperature within a permissible variation of ± 1 C. (± 1.8 F.). Satisfactory circulation of the air shall be secured by means of a fan. The compression device shall be centrally located in the oven and supported above the bottom of the oven by means of a wire rack mounted on wood or asbestos block so that it is heated by indirect heat.

Gages

8. A dial gage graduated in thousandths of an inch having a raised platform $\frac{3}{8}$ in. in diameter and a spherical foot $\frac{1}{4}$ in. in diameter, actuated by a load of 3 oz. ± 0.1 oz., shall be provided for measuring the thickness of the specimen before and after loading.

Standard Test Specimen

9. The standard test specimen shall be a cylindrical disk $\frac{1}{2}$ in. in thickness, cut from the vulcanized rubber part by means of a sharp, circular die having an inside diameter of 1.129 in. ±0.001 in. In cutting the specimen, the die shall be suitably rotated in a drill press or similar device and lubricated by means of soapy water so that a smooth-cut surface having square edges is obtained. The cutting pressure shall be kept sufficiently small to avoid "cupping" of the cut surface. When necessary,

the specimen thickness shall be reduced to the required ½ in. by cutting transversely with a sharp knife and carefully buffing to size within a permissible variation of ±0.005 in. The buffing shall be lightly done to avoid overheating and care must be taken to keep the circular faces parallel and at right angles to the axis of the cylinder.

Special Test Specimens

10. In routine production testing it is sometimes more convenient to cut test specimens of a different size and shape than that specified as standard. When any other size of specimen is used the test results shall not be compared with those secured using the standard test specimen. When using specimens of special sizes or shapes the results may be compared only with those from similar sizes and shapes.

Method A. Test for Compression Set Under Constant Load

Compression Device

11. The compression device shall consist of two parallel plates between which the test specimen is compressed and a calibrated loading spring, all mounted in a suitable housing having a screw mechanism for compressing the spring to apply the load and equipped with a scale graduated in hundredths of an inch for measuring the deflection of the spring. The device shall be portable, self-contained and capable of applying the desired load gradually and uniformly over the entire top and bottom surfaces of the test specimen for the duration of the test. A suitable compression device is shown in Fig. 1.

Spring

12. The loading spring shall be made of properly heat-treated spring steel with ends ground square and perpendicular to the longitudinal axis of the spring so as to help in keeping the plates parallel throughout the test. The spring shall conform to the following requirements:

(*a*) The spring shall be calibrated at room temperature (24 C. ± 5 C.) (75 F. ± 9 F.) by applying successive increments of load of 50 lb. ± 0.5 lb. and measuring the corresponding deflections in hundredths of an inch. The curve obtained by plotting the loads against the corresponding deflections shall have a slope of 4.0 ± 0.2 at 400-lb. load. The slope is obtained by dividing the difference between two loads expressed in pounds by the difference between the corresponding deflections expressed in hundredths of an inch.

NOTE.—*Example:* A spring which deflects 1.00 in. at 400 lb. and 0.75 in. at 300 lb. gives a slope of 4.0.

(*b*) The original dimensions of the spring shall not change due to fatigue by more than 0.01 in. after it has been mounted in the compression device, compressed under a 400-lb. load and heated in the oven for one week at 70 C. (158 F.). In ordinary use, a weekly check of the dimensions shall show no greater change than this over a period of 1 yr.

(*c*) The minimum load required to close the spring solid shall be 530 lb.

Original Thickness Measurement

13. The original average thickness of the test specimen shall be measured to the nearest 0.001 in. The specimen shall be placed on the small platform of the dial gage so that the pressure foot will indicate the thickness at the central portion of the top and bottom faces.

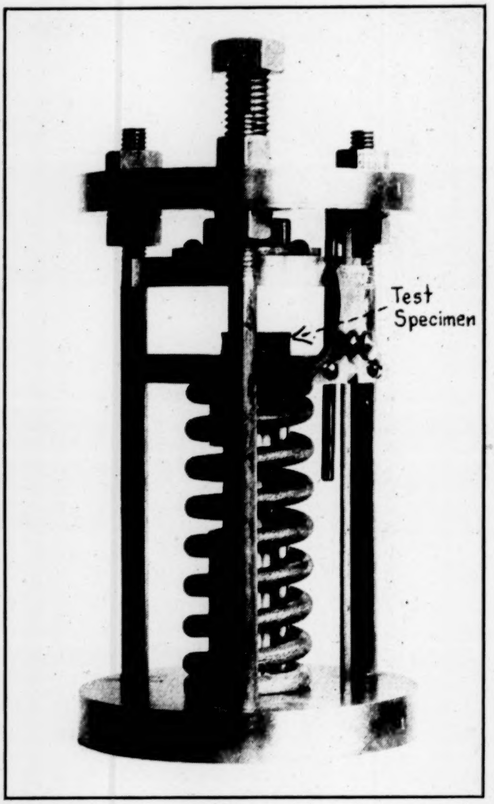

FIG. 1.—Device for Compression Set Test Under Constant Load.

Application of Load

14. The test specimen shall be assembled in the compression device using extreme care to place it exactly in the center between the plates so that tilting may be avoided. The spring shall be compressed by tightening the screw until the deflection as read from the scale is equivalent to that

shown on the calibration curve for the spring as corresponding to a load on the sample of 400 lb.

Heat Treatment

15. The assembled clamp shall be placed in the oven within 2 hr. after the completion of the assembly and shall remain there for 22 hr. in dry air at 70 C. (158 F.). At the end of the heating period the clamp shall be removed from the oven and the test specimen immediately taken from the clamp.

Cooling Period

16. While cooling, the test specimen shall rest on a wooden table top for 30 min. before the measurement of the final thickness is made.

Final Thickness Measurement

17. After the rest period, the final thickness shall be measured at the center of the test specimen using the dial gage described in Section 8.

Check Tests

18. Tests shall be run in duplicate but only one test specimen shall be tested at one time in each compression device. The duplicate test results should agree within 5.0 per cent of the values obtained.

Report

19. The report shall include the following:

(*a*) The original dimensions of the test specimen, including the original hickness, t_o.

(*b*) The actual load applied as determined from the calibration curve of the spring and the spring deflection reading.

(*c*) The thickness of the test specimen 30 min. after removal from the clamp, t_1.

(*d*) The compression set in inches and the percentage of the original thickness, calculated as follows:

$$\text{Compression set} = t_o - t_1$$

$$\text{Percentage compression set} = \frac{t_o - t_1}{t_o} \times 100$$

Method B. Compression Set Under Constant Deflection

Compression Device

20. The compression device shall consist of two or more flat steel plates between the parallel faces of which the specimens may be compressed as shown in Fig. 2. Steel spacers for the required percentage of compression given in Section 22 (*b*) shall be placed on each side of the rubber specimens to control their thickness while compressed. Four bolts shall pass through holes at the corners of the plates for compressing and holding the specimens.

Original Thickness Measurement

21. The original average thickness of the specimen shall be measured as described in Section 13.

Application of Load

22. (*a*) The test specimen shall be placed between the plates of the compression device with the spacers on each side of it. If only one specimen is being tested, it shall be placed in the center. If two specimens are being tested, three spacers shall be provided, one in the center and one outside of each specimen allowing sufficient clearance for the bulging of the rubber when compressed. The bolts shall be tightened so that the plates are drawn together uniformly until they are in contact with the spacers.

(*b*) The percentage of compression employed shall depend upon the hardness of the rubber according to the following table which is based on a value of approximately 25 in-lb. of work required to compress the standard specimen.

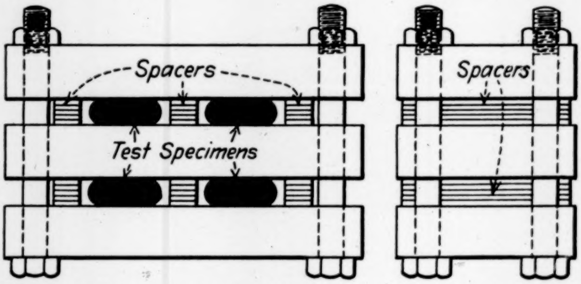

FIG. 2.—Device for Compression Set Test Under Constant Deflection.

A.S.T.M. HARDNESS NUMBER (3-LB. WEIGHT)	COMPRESSION OF RUBBER, PER CENT	SPACER THICKNESS, IN.
130 to 71	40	0.300
70 to 36	30	0.350
35 to 12	20	0.400

Heat Treatment

23. The heat treatment of the specimen shall be performed in accordance with Section 15.

Cooling Period

24. The specimen shall be cooled in accordance with Section 16.

Final Thickness Measurement

25. The final thickness of the specimen shall be measured as described in Section 17.

Check Tests

26. Tests shall be run in duplicate and the results should agree within 5.0 per cent of the values obtained.

Report

27. The report shall include the following:

(*a*) The original dimensions of the test specimen including the original thickness, t_o

(*b*) The percentage compression of the specimen actually employed.

(*c*) The thickness of the test specimen 30 min. after removal from the clamp, t_1

(*d*) The compression set in inches and the percentage of the original thickness, calculated as follows:

$$\text{Compression set} = t_o - t_1$$

$$\text{Percentage compression set} = \frac{t_o - t_1}{t_o} \times 100$$

TENTATIVE METHOD OF TEST

FOR

FASTNESS OF DYED OR PRINTED CCTTON FABRICS TO LAUNDERING OR DOMESTIC WASHING[1,2]

A.S.T.M. Designation: D 435 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1936.

Scope

1. This method of test applies to all colored cotton fabrics, whether dyed or printed, and deals only with the fastness of the color to laundering or domestic washing, without the aid of a bleaching agent.

Test Specimens

2. (*a*) Two specimens shall be cut from the piece of fabric to be tested; one specimen to be used for the test, and the other to be saved for comparison with the specimen used for the test.

(*b*) Each test specimen shall measure about 2 by 4 in., the longer dimension running in the direction of the warp. To the test specimen shall be sewed a piece of unsized bleached cotton cloth.

(*c*) In the case of printed fabric, if one specimen is not sufficiently large to include all of the colors in the design, a set of test specimens, each specimen 2 by 4 in. in size, shall be used for the test. The set shall consist of a sufficient number of specimens so cut as to include all of the colors in the design. Each specimen in the set shall be sewed onto a separate piece of unsized bleached cotton cloth, with the face of the print adjacent to the white cloth, and shall be washed in a separate jar. Duplicates of each specimen shall be saved for comparison purposes.

Apparatus

3. The washing test shall be carried out in a Launder-Ometer, or similar machine, equipped with a suitable heating device and thermostat for maintaining a constant temperature. The Launder-Ometer consists essentially of a copper tank, supported upon a rigid angle-iron frame. Within the tank there is a brass and aluminum rotor that carries 20 standard 1-pt. glass jars in which the tests are made. Each jar shall be securely

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee D-13 on Textile Materials.

[2] This tentative method is based upon the method which was developed by the Research Committee of the American Association of Textile Chemists and Colorists.

fastened with its base toward the horizontal shaft and 2 in. from the center of rotation. The shaft shall be rotated at a speed of 40 to 45 r.p.m. by means of a $\frac{1}{4}$-hp. motor on the outside of the tank.

Soap Solution

4. The soap solution shall contain 5 g. of 88 per cent soap and 2 g. of 58 per cent soda ash per liter. The soap shall be a good grade of neutral white chip, as free as possible from all substances other than true soap. Although the proportion of soap is calculated on the basis of 88 per cent soap, an equivalent amount of a soap having a higher or lower strength may be used. Distilled water, or water of approximately zero hardness, shall be used to dissolve the soap.

Method of Test

5. (*a*) *Washing.*—The Launder-Ometer, or similar machine, shall be half-filled with water which is heated to a temperature of 160 F. (71 C.). The test specimens shall be placed in the glass jars, each jar containing one specimen and 100 ml. of the soap and soda solution at 160 F. (71 C.). Ten $\frac{3}{8}$-in. rubber balls shall be added to each jar and the jars shall then be tightly closed and clamped to the rotor. They shall be rotated for 30 min., always maintaining the temperature of the water bath at 160 F. ± 2 F. (71 C. ± 1 C.). The specimens shall then be removed from the jars, rinsed thoroughly in warm distilled water 100 to 110 F. (38 to 43 C.) to insure complete removal of the soap, and wrapped in a clean white towel or similar cloth.

(*b*) *Drying.*—The excess water shall be removed by centrifuging or squeezing. The specimens shall be taken out of the towel and dried by pressing with a hot iron (but not hot enough to scorch white cloth) or a flat-plate ironer set at 275 to 300 F. (135 to 150 C.). After ironing, the specimens shall be allowed to condition in the open air for 2 hr., or until the colors reach a stable condition.

Classification

6. (*a*) The color of the test specimen shall be compared by eye with the color of the corresponding unwashed specimen. In making the comparison, the specimens shall always be held parallel to each other and viewed at the same angle under a standard daylight lamp or equivalent illumination.

(*b*) The bleached cloth which was sewed to the test specimen shall be examined for staining.

Results

7. (*a*) The fastness of the specimen shall be determined by a comparison with the fastness of a standard dyeing tested in the same way and at the same time.

(*b*) The standard dyeing for this test shall be prepared by dyeing a cotton fabric with 1 per cent of its weight of Diaz Fast Violet BL and then developing this dyeing with Beta Naphthol.

NOTE.—Standard dyeings have been prepared by the American Association of Textile Chemists and Colorists and are available for general use.

(*c*) If the test specimen is equal in fastness to the standard dyeing, it shall be classed as fast to laundering or domestic washing, without the aid of a bleaching agent.

TENTATIVE METHODS OF TESTING AND TOLERANCES
FOR
CERTAIN CARDED COTTON GRAY GOODS[1]

A.S.T.M. Designation: D 433 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1936.

Scope

1. These methods of testing and tolerances apply to the following carded cotton gray goods: Broadcloth, buckram, bunting, carded lawns, clothing twills, cotton flannel, denims, drills, four leaf twills, osnaburg, pajama checks, pillow tubing, pocketing twills, print cloths, sateens, sheetings, twills.

Sampling

2. (*a*) Samples for testing shall be so selected as to be representative of the lot.

(*b*) In the event of any controversy concerning specifications or quality of the material, the samples selected to represent any lot shall be single pieces from bales constituting the early, middle and late parts of the lot, in order of time of delivery, or in the case of a single delivery in order of serial package numbers. The pieces selected shall constitute not less than 3 per cent of the lot, by yardage, and shall be selected from packages constituting not less than 10 per cent of the lot.

TOLERANCES

Tolerances

3. Tolerances are the limits within which the specified characteristics of the fabric must come to constitute a good delivery on contract (Note).

NOTE.—Deficiency limits and allowances for variations in excess of the specified tolerances shall be as fixed by the purchase specifications.

Yardage

4. The yardage of the lot, when specified, shall not vary from that specified by less than or greater than half of an average bale. For quanti-

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-13 on Textile Materials.
These methods of test and tolerances conform in substance, but not in form, with Specification G of the Worth Street Rules, 1936.

ties less than 10,000 yd. the yardage shall not vary more than ±5 per cent of that specified.

Selvage

5. The number of warp ends in the selvage of the fabric shall be equal to that of the standard sample submitted, or in the absence of a standard sample, to the mill standard.

Width

6. (*a*) The width of the fabric, within 2 yd. of either end of each piece, shall approximate that specified.

(*b*) The width of the fabric throughout the remainder of each piece shall not vary anywhere by more than 1 per cent below or 2 per cent above the specified width.

(*c*) The average width of the fabric in a lot shall equal or exceed the specified width.

Count, Warp

7. (*a*) The number of warp ends per inch within 4 in. of the selvages and 2 yd. of either end of each piece of the fabric shall approximate the specified count.

(*b*) The number of warp ends per inch throughout the remainder of each piece of the fabric shall not vary anywhere by more than 3 per cent below or 4 per cent above the specified count.

(*c*) The number of warp ends in each piece of the fabric, exclusive of selvages, shall be not less than that calculated by multiplying the specified width less the width of the selvages, by the specified warp count.

Count, Filling

8. (*a*) The number of picks per inch, within 2 yd. of either end of each piece of the fabric, shall approximate the specified count.

(*b*) The number of picks per inch throughout the remainder of each piece of the fabric shall not vary anywhere by more than 5 per cent below or 7 per cent above the specified count.

(*c*) The average number of picks per inch of the fabric in a lot shall equal or exceed the specified count.

Weight

9. (*a*) The weight of the fabric in any piece shall not vary by more than 4 per cent below or 6 per cent above the specified weight.

(*b*) The weight of the fabric in any bale shall not vary by more than $2\frac{1}{2}$ per cent below or 4 per cent above the specified weight.

(*c*) The average weight of the fabric in a lot shall not vary by more than 0.75 per cent below or 2 per cent above the specified weight.

METHODS OF TESTING

Standard Methods

10. All test procedures not otherwise specified shall be in accordance with the Standard General Methods of Testing Woven Textile Fabrics (A.S.T.M. Designation: D 39) of the American Society for Testing Materials.[1]

Width

11. (*a*) The width of the fabric in any piece shall be determined by laying the fabric on a flat, horizontal surface, smoothed out by hand but not stretched, and measuring the width perpendicular to the selvages. The selvages shall be included in the measurement of width.

(*b*) The average of measurements made at 10-yd. intervals shall be the width of the piece.

(*c*) The average width of any lot of the fabric shall be that obtained by averaging the widths of the pieces selected to represent it.

Count, Warp

12. (*a*) The warp count of any piece of the fabric shall be determined by counting the number of ends (warp yarns or threads) in six 1-in. spaces distributed as follows: three across the piece approximately 2 yd. from one end, and three across the middle of the piece. The spaces counted shall be separated by a distance not less than one-quarter of the width of the piece. No determination shall be taken within 4 in. of either selvage.

(*b*) The average of the six determinations shall be the warp count of the piece.

Count, Filling

13. (*a*) The filling count of any piece of the fabric shall be determined by spreading the fabric flat at full width and counting the number of picks (filling yarns or threads) in 1-in. spaces distributed at intervals of 4 yd. along the length of the piece. No space counted shall include pick bars.

(*b*) The average of the determinations shall be the filling count of the piece.

(*c*) The average filling count of any lot shall be that obtained by averaging the filling counts of the pieces selected to represent it.

Weight

14. (*a*) The pieces of fabric selected as representative of the lot shall be conditioned for 24 hr. in an atmosphere having a relative humidity of 65 per cent at 70 F. (21 C.).

(*b*) If not practical to condition full pieces, a sample shall be taken near, but not from, each end of the piece and conditioned as in Paragraph (*a*). These samples shall be taken the full width of the piece and of an accurately measured length not less than ½ yd.

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 1334.

(*c*) The piece or samples shall be weighed on a calibrated scale, the length of the piece or samples shall be measured, and the weight of the piece in linear yards per pound shall be calculated.

(*d*) The average weight of a bale or lot of the fabric shall be obtained by averaging the weights of the pieces selected to represent it.

TENTATIVE METHODS OF TESTING AND TOLERANCES
FOR
WOVEN TAPES[1]

A.S.T.M. Designation: D 259 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED AS TENTATIVE, 1926; ADOPTED, 1927; REISSUED AS TENTATIVE, 1931;
REVISED, 1936.

Scope

1. These methods of testing and tolerances apply to silk and cotton tapes.

TOLERANCES

Tolerances

2. Tolerances are the limits within which the specified characteristics of the textile must come to constitute a good delivery on contract.

Thickness

3. (*a*) The average thickness of the tape shall not vary from that specified by more than the following amounts:

NOMINAL THICKNESS	PERMISSIBLE VARIATIONS, IN.
0.011 in. and under	±0.001
Over 0.011 in. up to and including 0.020 in	±0.0015

(*b*) Individual thickness measurements shall not vary from the nominal thickness specified by more than the following amounts:

NOMINAL THICKNESS	PERMISSIBLE VARIATIONS, IN.
0.011 in. and under	±0.0015
Over 0.011 in. up to and including 0.020 in	±0.002

Width

4. The width of the tape shall not vary from that specified by more than the following amounts:

NOMINAL WIDTH, IN.	PERMISSIBLE VARIATIONS, IN.
$\frac{1}{2}$	$\pm\frac{1}{32}$
$\frac{3}{4}$	$\pm\frac{1}{32}$
1	$\pm\frac{3}{64}$
$1\frac{1}{4}$	$\pm\frac{3}{64}$
$1\frac{1}{2}$	$\pm\frac{3}{64}$
Over $1\frac{1}{2}$	$\pm\frac{1}{16}$

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-13 on Textile Materials.
These tentative specifications are in effect a revision of the former Standard Specifications for Tolerances and Test Methods for Electrical Silk and Cotton Tapes (A.S.T.M. Designation: D 259 - 27), which standard was accordingly discontinued in 1933.

Weight

5. The average weight of the tape shall be calculated in yards per pound and in no case shall the yardage be less than that specified.

Construction

6. The total number of ends shall be not less than specified. The picks per inch shall not vary more than the following:

±1 pick for tapes counting up to and including 48 per inch;
±2 picks for tapes counting over 48 per inch.

METHODS OF TESTING

Sampling Rolls for Test

7. From each shipment of tape at least three rolls shall be selected and the tests outlined shall be made on each roll. Failure of the first samples selected to conform to the requirements of the specifications will necessitate a selection of the same number of rolls for a second test.

Thickness

8. The thickness of the tape shall be determined in accordance with Method B of the Tentative Methods of Test for Thickness of Solid Electrical Insulation (A.S.T.M. Designation: D 374 - 36 T) of the American Society for Testing Materials.[1]

Number of Thickness Measurements

9. At least ten measurements shall be taken on the samples used for weight determination (Section 11) and the average and range of thickness recorded.

Width

10. The width of the tape shall be determined by the use of a standard steel scale graduated to read within the degree of accuracy specified for width tolerances in Section 4. The tape shall lay flat on a smooth surface at the time of measurement.

Number of Width Measurements

11. At least ten measurements shall be taken on the samples used for weight determination (Section 11) and the average and range of width recorded.

Weight

12. The weight of the tape shall be determined by accurately measuring and weighing samples 2 yd. in length and then calculating the yards per pound.

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[1] See p. 1026.

Number of Weight Tests

13. Not less than three weight determinations shall be made per shipment, such determinations to be made on different rolls from different packages. The average of these three determinations shall indicate the average of the shipment involved.

Construction

14. The total number of ends shall be determined irrespective of the width of the tape.

Picks

15. The number of picks shall be determined in a length of 1 in.

Number of Count Tests

16. The number of ends shall be taken as that secured by making one determination per sample. The number of picks shall be taken as the average of three counts made at different places on the sample. An accepted thread counting magnifying glass shall be used in making the counts.

Tensile Strength

17. (*a*) The tensile strength of the tape shall be determined on a testing machine which conforms to the requirements of the Standard Specifications for Textile Testing Machines (A.S.T.M. Designation: D 76) of the American Society for Testing Materials,[1] and tests shall be made in the direction of warp only. Test results, where specimens break in the jaws of the testing machine, shall be discarded.

(*b*) The specimens shall be tested in full section and the distance between jaws shall be 3 in.

Number of Tension Tests

18. At least five strength determinations shall be made and the average of these five tests shall indicate the strength of the roll.

Sizing Content

19. Total sizing content of the tape shall be determined in accordance with Section 3 of the Tentative Methods for the Identification of Fibers in Textiles and for the Quantitative Analysis of Textiles (A.S.T.M. Designation: D 276 - 35 T) of the American Society for Testing Materials.[2] Tests shall be made on a composite sample of approximately 5 g.

Acidity Test Apparatus

20. (*a*) The determination of acidity or alkalinity of tapes shall be determined on any standard commercial quinhydrone pH indicator having a sensitivity and accuracy of 0.02 pH. A suitable and approved type of indicator, its preparation and maintenance, are described in the following Paragraphs (*b*) to (*l*).

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 1291.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 1215 (1935); also 1936 Book of A.S.T.M. Tentative Standards, p. 1172.

(*b*) *Potassium Chloride - Calomel Electrode.*—A potassium chloride-calomel electrode assembly is shown in Fig. 1 in which the outside tubes *A* and *E* together with the ground glass joint *F* comprise the salt bridge, while *B* is the calomel electrode.

(*c*) *Potassium Chloride.*—A stock solution of potassium chloride shall be prepared by adding c.p. potassium chloride to hot distilled water until saturated and the solution allowed to cool. The solution shall be kept in contact with solid potassium chloride. Before adding to the salt bridge the solution shall be cooled to the lowest temperature at which the test solution will be used. This will prevent crystallization in the salt bridge during use.

(*d*) *Calomel Electrode, Cleaning.*—The calomel electrode, *B*, shall be cleaned by immersing the lower half in a nitric acid solution consisting of equal volumes of water and HNO_3 (sp. gr. 1.42), heating the solution gradually to 45 C. (113 F.) and allowing it to cool. The electrode shall then be removed from the acid solution and shall be washed thoroughly with distilled water, and finally with alcohol, and thoroughly dried.

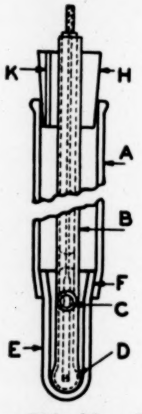

FIG. 1.—Potassium Chloride - Calomel Electrode.

(*e*) *Calomel Electrode, Filling.*—The small bulb, *D*, of the calomel electrode shall be half filled with 1 to 1.2 g. of specially purified mercury by introducing it through the hole *C* by means of a small pipette. Enough mercurous chloride shall be introduced through *C* to fill the remainder of the bulb *D*. Two drops of saturated potassium chloride (Paragraph (*c*)) shall be added to moisten the mixture of mercury and mercurous chloride. A small piece of filter paper shall be held with the finger over the hole *C* and the electrode shall be vigorously shaken to form an emulsion of the mercurous chloride and mercury globules. The electrode shall be placed in a small beaker containing saturated potassium chloride solution and allowed to stand until the excess calomel has settled into the bulb *D*. The electrode shall be tapped to remove air bubbles. No air shall be left in the element *B* after filling it with saturated potassium chloride solution.

(*f*) *Salt Bridge.*—Parts *A* and *E* of the salt bridge shall be separately cleaned with chromic acid cleaning solution. The cleaned parts shall be thoroughly washed with distilled water, then with alcohol, and thoroughly dried. The salt bridge shall be assembled by inserting tube *E* into tube *A* as indicated in Fig. 1. Enough saturated potassium chloride solution (Paragraph (*c*)) shall be added to fill the assembled salt bridge approximately one-third full. While holding the tube *A* in a fixed position the tube *E* shall be rotated a slight amount to allow a few drops of the potassium chloride solution to drain out and moisten the ground glass joint *F*. The tube *E* shall be seated gently with a downward twisting motion but not so firmly as to prevent maintaining a moist surface in the joint *F* since the film of potassium chloride solution around the joint *F* forms a part of the electrical circuit.

(*g*) *Assembly.*—The calomel electrode *B* shall be inserted in the salt bridge as indicated in Fig. 1, adjusting the position of *B* in the cork *H* so that the bulb *D* rests on the bottom of tube *E*. With the bulb *D* resting on the bottom of the tube *E* the level of the potassium chloride solution shall be above the level of the solution being measured when the top of the ground glass joint *F* is at least $\frac{1}{2}$ in. below the level of the solution being measured.

(*h*) *Maintenance.*—The following points shall be observed in maintaining the calomel-electrode assembly in satisfactory working condition:

(*1*) Inspect the breather hole *K* in the stopper *H* daily and see that it is kept open.

(*2*) Flush the salt bridge daily by turning the tube *E* slightly to allow a few drops of the potassium chloride solution to flow out and reseating *E*, if necessary, as directed in Paragraph (*f*).

(*3*) Maintain the level of the potassium chloride solution as directed in Paragraph (*g*).

(*4*) If the calomel electrode appears to become insensitive (as is evidenced by the galvanometer pointer swinging free, independent of changes in pH), flush the salt bridge as directed in (*2*) above.

(*i*) *Electrode, Platinum or Gold.*—A platinum or gold electrode for use with quinhydrone shall be prepared by fusing a piece of thin platinum or gold ribbon, about 1 sq. cm. in area, through the end of a glass tube. The glass tube shall be filled with ordinary mercury for contact with the wire lead.

(*j*) *Potentiometer.*—The potentiometer shall be sensitive to at least 0.001 v.

(*k*) *Galvanometer.*—The galvanometer shall be sensitive to at least 0.001 v.

(*l*) *Standard Cell and Battery.*—A Weston or similar standard cell and a 2-v. battery will be required.

Acidity Test Procedure

21. (*a*) *Apparatus Assembly.*—Figure 2 illustrates the apparatus set up showing the two electrodes on the right connected with potentiometric equipment and standard dry cell.

(*b*) The solution for the acidity test shall be prepared by placing a 10-g. sample of the tape in a Soxhlet extractor and adding sufficient water to cover it. The extraction shall be carried on for a period of 2 hr. The solution thus obtained shall be transferred to a flask and diluted with recently boiled and cooled distilled water to give a volume of 250 ml. The whole or any portion of this solution may be used for making the pH determination.

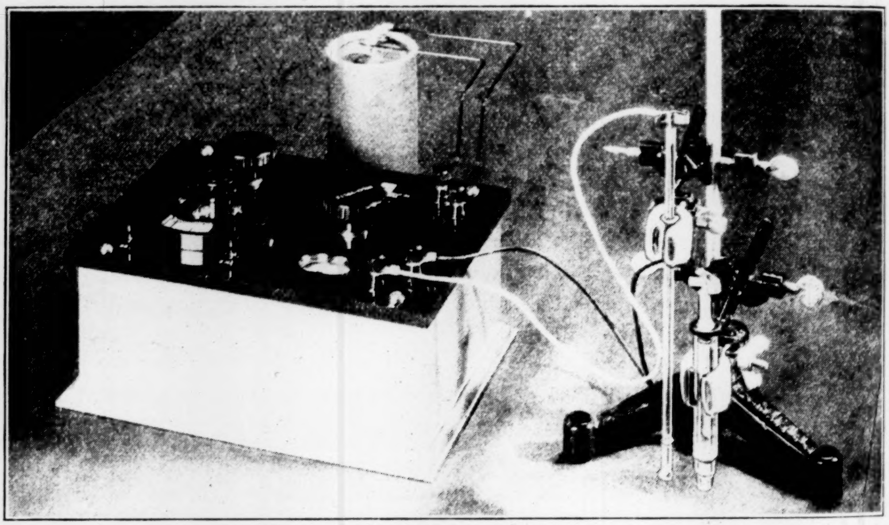

FIG. 2.—Quinhydrone pH Indicator.

(*c*) The potassium chloride - calomel electrode shall be inserted into the prepared test solution (Paragraph (*a*)) so that the end of the electrode extends well below the level of the solution. The platinum or gold electrode shall be inserted into the solution at the opposite side of the calomel electrode. It shall be so placed that the ribbon is well below the level of the solution. The electrodes, potentiometer, galvanometer, Weston or similar standard cell, and the 2-v. battery shall be connected so as to measure the voltage between the electrodes (Fig. 2). The potentiometer and temperature readings shall be immediately taken. The pH value shall be determined from standard tables. During the whole procedure care shall be taken to prevent contamination of the test solution by gases which may be present in the surrounding atmosphere. Duplicate tests shall be made on composite samples of the tape and the pH value reported for each sample.

Failure

22. Failure of any of the tape to conform to the requirements of these specifications will make the shipment the subject of complaint and disposition in accordance with the agreement between the purchaser and seller.

Retests

23. In case of dispute, tests shall be made on material under standard conditions as defined in Section 3 of the Standard General Methods of Testing Woven Textile Fabrics (A.S.T.M. Designation: D 39) of the American Society for Testing Materials.[1]

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[1] 1936 Book of A.S.T.M. Standards, Part II, p. 1334.

TENTATIVE METHOD OF TEST

FOR

FASTNESS OF DYED OR PRINTED SILK OR RAYON FABRICS TO LAUNDERING OR DOMESTIC WASHING[1,2]

A.S.T.M. Designation: D 436 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St, Philadelphia, Pa.

ISSUED, 1936.

Scope

1. This method of test applies to all colored fabrics containing substantial amounts of silk or rayon, whether dyed or printed, and deals only with the fastness of the color to laundering or domestic washing without the aid of a bleaching agent.

Test Specimens

2. (*a*) Two specimens shall be cut from the piece of fabric to be tested; one specimen to be used for the test, and the other to be saved for comparison with the specimen used for the test.

(*b*) Each test specimen shall measure about 2 by 4 in., the longer dimension running in the direction of the warp. To the test specimen shall be sewed pieces 1-in. square of unsized bleached cotton and undyed silk, wool, rayon and cellulose acetate fabrics.

(*c*) In the case of printed fabrics, if one specimen is not sufficiently large to include all of the colors in the design, a set of test specimens, each specimen 2 by 4 in. in size, shall be used for the test. The set shall consist of a sufficient number of specimens so cut as to include all of the colors in the design. Each specimen in the set shall have sewed to it, on the face side of the print, undyed pieces of fabrics as described in Paragraph (*b*), and shall be washed in a separate jar. Duplicates of each specimen shall be saved for comparison purposes.

Apparatus

3. The washing test shall be carried out in a Launder-Ometer, or similar machine, equipped with a suitable heating device and thermostat for maintaining a constant temperature. The Launder-Ometer consists

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee D-13 on Textile Materials.

[2] This tentative method is based upon the method which was developed by the Research Committee of the American Association of Textile Chemists and Colorists.

essentially of a copper tank, supported upon a rigid angle-iron frame. Within the tank there is a brass and aluminum rotor that carries 20 standard 1-pt. jars in which the tests are made. Each jar shall be securely fastened with its base toward the horizontal shaft and 2 in. from the center of rotation. The shaft shall be rotated at a speed of 40 to 45 r.p.m. by means of a $\frac{1}{4}$-hp. motor on the outside of the tank.

Soap Solution

4. The soap solution shall contain 5 g. of 88 per cent soap per liter. The soap shall be a good grade of neutral white chip, as free as possible from all substances other than true soap. Although the proportion of soap is calculated on the basis of 88 per cent soap, an equivalent amount of a soap having a higher or lower strength may be used. Distilled water, or water of approximately zero hardness, shall be used to dissolve the soap.

Method of Test

5. (*a*) *Washing.*—The Launder-Ometer, or similar machine, shall be half-filled with water which is heated to a temperature of 100 F. (38 C.). The test specimens shall be placed in the glass jars, each jar containing one specimen and 100 ml. of the soap solution at 100 F. (38 C.). The jars shall be tightly closed and clamped to the rotor. They shall be rotated for 30 min., always maintaining the temperature of the water bath at 100 F. ± 1 F. (38 C. ± 0.5 C.). The specimens shall then be removed from the jars, rinsed thoroughly in warm distilled water 100 to 110 F. (38 to 43 C.) to insure complete removal of the soap, and wrapped in a clean white towel or similar cloth.

(*b*) *Drying.*—The excess water shall be removed by centrifuging or squeezing. The specimens shall be taken out of the towel and dried by pressing with a moderately warm, not hot, iron or a flat-plate ironer set to about 275 F. (135 C.). After ironing, the specimens shall be allowed to condition in the open air for 2 hr., or until the colors reach a stable condition.

Classification

6. (*a*) The color of the test specimen shall be compared by eye with the color of the corresponding unwashed specimen. In making the comparison, the specimens shall always be held parallel to each other and viewed at the same angle under a standard daylight lamp or equivalent illumination.

(*b*) The undyed fabrics which were sewed to the test specimen shall be examined for staining.

Results

7. (*a*) The fastness of the specimen shall be determined by a comparison with the fastness of a standard dyeing tested in the same way and at the same time.

(*b*) The standard dyeing for this test shall be prepared by dyeing an all-silk fabric with 1 per cent of its weight of Formyl Violet S4B (Color Index No. 698).

NOTE.—Standard dyeings have been prepared by the American Association of Textile Chemists and Colorists and are available for general use.

(*c*) If the test specimen shows no greater loss in color or staining of the undyed fabrics than the standard dyeing during the test, it shall be classed as fast to laundering or domestic washing, without the aid of a bleaching agent.

TENTATIVE METHOD OF TEST
FOR
RESISTANCE TO YARN SLIPPAGE IN SILK, RAYON, AND SILK-RAYON WOVEN BROAD GOODS[1]

A.S.T.M. Designation: D 434 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1936.

Scope

1. This method of test applies to the measurement of the resistance to slippage of filling yarns on warp yarns, or warp yarns on filling yarns, in silk, rayon, and silk-rayon woven broad goods.

Resistance to Slippage

2. Resistance to slippage is the pounds pull (across a seam) per inch of width necessary to produce an elongation of $\frac{1}{4}$ in. in excess of the normal stretch of the fabric under the same load. (See Note 1.)

Testing Machine

3. The testing machine shall be an approved pendulum type with a maximum capacity of 50 lb. (or 25 kg.). It shall be equipped with an autographic recording device and with clamps having front anvils 1 in. in width and back anvils 2 in. or more in width, except as otherwise provided (see Note 2). The clamps shall be set 3 in. apart. The speed of the lower clamp shall be 12 in. ± $\frac{1}{2}$ in. per minute.

Direction of Pull

4. The direction of the pull shall be that (in line with filling or warp) in which the smaller force is required to produce slippage as indicated by preliminary tests (Section 8).

Test Specimens

5. (*a*) *Preparation of the Specimens.*—For the preparation of one specimen, two pieces of fabric are required, one 4 by 4 in. and one 4 by 10 in., cut with the long sides parallel to the filling yarns (see Note 3). The 4 by 4-in. piece shall be laid on the 4 by 10-in. piece in such a manner

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee D-13 on Textile Materials.

that the filling yarns in each piece run in the same direction, and the end of one piece is superimposed on the end of the other. The pieces shall be sewed together across the 4-in. end and ½ in. from the end, using a needle approximately 0.030 in. in diameter, No. 00 white mercerized cotton thread and 14 stitches to the inch. A plain stitch (see Note 4) shall be used. It is important that the stitches be made under uniform tension and that the seam be perpendicular to the filling yarns.

(*b*) *Specimens for Preliminary Test.*—Two specimens shall be prepared (Paragraph (*a*)) as follows: Specimen *A* with seam perpendicular to direction of filling, and specimen *B* with seam perpendicular to direction of warp. Specimen *A* is used for determining the resistance to slippage of warp on filling, and specimen *B* for determining the resistance to slippage of filling on warp.

(*c*) *Specimens for Final Determination.*—Five specimens shall be prepared (Paragraph (*a*)) after the manner of either specimens *A* or *B* (Paragraph (*b*)), which ever is shown by the preliminary test (Section 8) to require the smaller force to produce a slippage of ¼ in.

Conditioning

6. All specimens being tested, except those for preliminary test, shall be conditioned for at least 4 hr. in an atmosphere having a relative humidity of 65 per cent at 70 F. (21 C.). A tolerance of ± 2 per cent is permitted in relative humidity and plus 10 F. (6 C.) in temperature.

Test Procedure

7. (*a*) In all tests the specimen shall be placed squarely in the upper clamp and securely gripped. The specimen shall then be securely gripped in the lower clamp, care being taken to grip the same yarns in both clamps. In order to obtain a proper alignment, it has been found helpful, after gripping the specimen in the upper clamp, to attach to the lower end of the specimen an auxiliary clamp weighing 6 oz. and having anvils at least 4 in. in width. The pen shall then be placed on the zero vertical ordinate of the chart as directed under the specific tests.

(*b*) *Load-Elongation Curve for Fabric.*—The 4 by 10-in. part of the specimen shall be gripped in the clamps of the testing machine (Paragraph (*a*)), the end opposite the seam being placed in the upper clamp. Beginning with the pen at the zero-zero point on the chart, the machine shall be started and the load-elongation curve autographically recorded.

(*c*) *Load-Elongation Curve for Fabric and Seam.*—The specimen shall be gripped in the clamps of the machine (Paragraph (*a*)) with the seam located midway between the upper and lower clamps. Beginning with the pen on the vertical zero ordinate and on any convenient abscissa line, the machine shall be started and the load-elongation curve autographically recorded.

Preliminary Tests

8. (*a*) Preliminary tests are necessary to determine in which direction the smaller force is required to produce slippage. Pulling between the thumb and forefinger may be sufficient. If a machine test is necessary, the procedure given in Paragraph (*b*) shall be followed.

(*b*) To determine in which direction the smaller force is required to produce slippage, specimens *A* and *B* (Section 5 (*b*)) shall be used. Load-elongation curves shall be determined for each specimen; that for the fabric in accordance with Section 7 (*b*) and that for the fabric and seam in accordance with Section 7 (*c*). The resistance to slippage shall be calculated as directed in Section 10.

Final Tests

9. (*a*) Specimens shall be prepared in accordance with Section 5 (*c*) and conditioned (Section 6).

(*b*) *Load-Elongation Curve for Fabric.*—Three specimens shall be used. The load-elongation curves (Section 7 (*b*)) of the three specimens shall be recorded on the same chart, starting each curve at the zero-zero point (see Note 5). If the three curves superimpose closely, the average shall be used as the load-elongation curve. If the three curves do not superimpose closely, the remaining two specimens shall be tested in the same manner, and the average of all five specimens shall be taken. If satisfactory checks cannot be obtained, a new set of specimens shall be prepared.

(*c*) *Load-Elongation Curve for Fabric and Seam.*—The curve (Section 7 (*c*)) for each of the five specimens shall be recorded, starting each curve at a different point on the zero vertical ordinate (see Note 6).

Calculation of Results

10. (*a*) The average load-elongation curve for the fabric and the chart coordinates shall be traced on a thin sheet of paper (see Note 5).

(*b*) This tracing shall be placed on a "load-elongation curve for fabric and seam" in such a manner that the origins of the two curves and the chart coordinates are superimposed (Fig. 1). A pair of dividers shall be set at the points B and C (Fig. 1), where the two curves cross the 1-lb. (or 0.5-kg.) ordinate. This distance between the two curves is called the "compensation." The dividers shall then be placed on a scale and opened an additional distance corresponding to ¼-in. slippage (½ in. for a 2:1 ratio of magnification).

(*c*) With the dividers set as in Paragraph (*b*), and with one point on the traced curve, proceed up the traced curve until the other point rests on the load-elongation curve for the fabric and seam, with both points resting on the same vertical ordinate. The force in pounds or kilograms at this position is that necessary to produce a slippage of ¼ in., based on

1 in. of fabric width. From the force thus obtained subtract 1-lb. (or 0.5-kg.) "compensation." The remainder is designated as the resistance to slippage. (If 2-in. front anvils are used, divide the final results by two.) Kilograms may be converted to pounds by multiplying by 2.2.

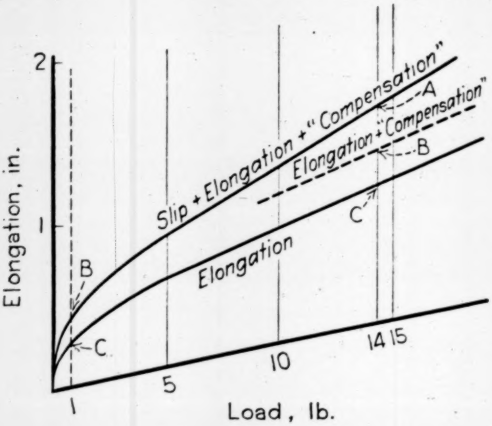


FIG. 1.—Slippage Chart.

A to B = Distance equivalent to $\frac{1}{4}$-in. slip ($\frac{1}{2}$ in. when ratio of chart distance to slip distance is 2:1)
B to C = "Compensation" at 1 lb.
Slippage of fabric was at 14-lb. reading, or 14 − 1 = 13 lb. per in., corrected.

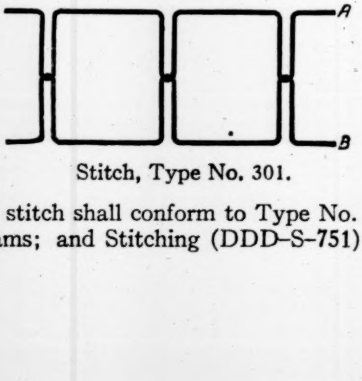
(*d*) The average of five tests shall be the resistance to slippage.

EXPLANATORY NOTES

NOTE 1.—It is recommended that fabrics be tested in original condition and also after laundering, or dry cleaning or both, depending upon the intended use of the material.

NOTE 2.—If the resistance to slippage is less than 10 lb. (or 4.5 kg.), the front anvils of the clamps shall be 2 in. in width. The approximate resistance to slippage may be determined in accordance with Section 8.

NOTE 3.—In the above directions for the preparation of a sample, it is assumed, for simplicity, that the sample is to be used for determining the slippage of the warp on the filling, that is, the sample will be subjected to a pull in line with the direction of the filling. In case the sample is to be prepared for determining slippage of the filling on the warp, it is only necessary to read "warp" instead of "filling" in directions given above.



Stitch, Type No. 301.

NOTE 4.—The plain stitch shall conform to Type No. 301 of the Federal Specification for Stitches; Seams; and Stitching (DDD-S-751) of the Federal Specifications Board. This type of stitch shall be formed of two threads. A loop of one thread shall be passed through the material where it shall be entered by the mass supply of the other thread. The loop of the first thread then shall be drawn into the material to the extent that the concatenation is approximately halfway between the two surfaces of the material. These operations are repeated to form a sequence of stitches.

NOTE 5.—If preferred, instead of developing an average load-elongation curve for the fabric, the "load-elongation curve for the fabric" and the "load-elongation curve for the fabric and seam" for each specimen may be started from the same origin, thus giving a pair of curves representative of that specimen. Each pair of curves should be started from a different point on the zero ordinate. Resistance to slippage may then be measured from each pair of curves without recourse to tracing.

NOTE 6.—If the load-elongation curve is serrated, a smooth curve shall be drawn through the tips of the serrations.

TENTATIVE METHODS OF TESTING PILE FLOOR COVERING[1]

A.S.T.M. Designation: D 418 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1935; REVISED, 1936.

Scope

1. These methods of testing are intended to be applicable for testing pile floor coverings.

Sampling

NOTE.—The size of dissection samples and methods of sampling will be covered in later revisions of these methods.

Condition

2. (*a*) *Unconditioned.*—The weight of the fabric when samples for weight determination are cut from it is the unconditioned weight. A specification of the weight of a fabric must also specify the moisture condition.

(*b*) *Oven-Dry Condition.*—The oven-dry condition of pile fabrics is that state of dryness obtained on equilibrium of the material in a ventilated drying oven maintained at a temperature of 220 to 230 F. (105 to 110 C.).

(*c*) *Standard Condition.*—Standard condition of pile fabric is that reached by the fabric when in moisture equilibrium with a standard atmosphere having a relative humidity of 65 per cent at 70 F. (21 C.). A tolerance of ± 2 per cent is permitted in relative humidity and plus 10 F. (6 C.) in temperature.

(*d*) *Moisture Equilibrium.*—It shall be considered that moisture equilibrium is reached when, after free exposure to the standard atmosphere in motion, two successive weighings not less than 30 min. apart show not more than 1.0 per cent change in weight. Equilibrium shall be approached from the dry side (not oven dry).

Test Condition

3. All fabrics shall be tested under standard conditions as described in Section 2 (*c*).

QUANTITY

Length

4. The length of a roll or piece shall be determined by running the fabric over a measuring drum of known circumference, from which the

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-13 on Textile Materials.

yardage is registered by a dial or counter driven by a chain, or other positive non-slip mechanism. This yardage shall be the length of the fabric and shall be independent of any effect of its thickness.

Width

5. (*a*) The width of a roll or piece shall be determined at five different places uniformly distributed along the full length of the roll or piece, and may be determined at the same time as the total length.

(*b*) Measurements shall be made to the nearest $\frac{1}{16}$ in.

(*c*) The average of the five measurements shall be the width.

Weight

6. (*a*) *Unconditioned Weight.*—Samples in a condition which is the same as the fabric they represent shall be rapidly weighed on a balance sensitive to 0.1 per cent of the total weight. The average of these weights shall be the unconditioned weight of the samples.

(*b*) *Conditioned Weight.*—The samples shall be allowed to come to standard condition as described in Section 2 (*c*). The average of the samples weighed under standard conditions shall be the conditioned weight of the samples and shall be used to calculate the conditioned weight of the fabric.

(*c*) *Oven-Dry Weight.*—One of the samples shall then be converted to the oven-dry condition as described in Section 2 (*b*). This shall be the oven-dry weight of the sample.

Moisture Content and Regain

7. (*a*) *Weight of Moisture.*—The difference between the unconditioned weight (Section 6 (*a*)) and the oven-dry weight (Section 6 (*c*)) shall be the weight of moisture present.

(*b*) *Moisture Content.*—The weight of moisture when calculated as a percentage of the unconditioned weight shall be the "moisture content" of the fabric.

(*c*) *Moisture Regain.*—The weight of moisture when calculated as a percentage of the oven-dry weight shall be the "moisture regain" of the fabric.

Total Thickness

8. Thickness of a fabric shall be determined by measuring to the nearest 0.001 in. the distance between the two plane surfaces of a fabric under a pressure of 0.100 ± 0.001 lb. per sq. in. distributed over a circular area 3.00 in. ± 0.01 in. in diameter. The pressure shall be applied slowly to avoid impact, and the fabric shall be protected from vibration during test. The average of five readings taken at different places, uniformly distributed over the area of the surface, shall be the thickness.

CONSTRUCTION

Back Thickness

9. The pile yarn shall be removed from a section of the fabric by clipping. A 5-in. diameter metal ring shall be seated on the clipped portion, a flame directed on the area within the ring, and the pile destroyed with alternate charring and brushing without damage to the back construction. The thickness of the remaining back construction shall be determined by measuring to the nearest 0.001 in. the distance between the two plane surfaces of the back construction under a pressure of 0.750 lb. ± 0.001 lb. per sq. in. distributed over a circular area 1.00 in. ± 0.01 in. in diameter. The pressure shall be applied slowly to avoid impact and the fabric shall be protected from vibration during test. The average of five readings taken at different places within the exposed back construction shall be the back thickness of the sample.

Net Pile Height

10. The net pile height is the difference between the total thickness and the back thickness, as determined in Sections 8 and 9.

Rows

11. The number of rows of tufts per inch shall be determined by counting a space of not less than 10 in. in at least three different places. No two count determinations shall include the same rows. The row count of the fabric shall be the average of the number of rows per inch in these three tests.

Pitch

12. The number of pile ends per inch of width shall be determined by counting the tufts in a space of not less than 10 in. in at least three different places staggered across the piece. The pitch of the fabric shall be the average of the number of pile ends per inch found in these three tests.

Shot

13. The number of shots in a single repeat of the weaving cycle, or the number of travels of filling yarn per row of tufts, shall be noted. This number shall be the shot of the fabric. In Axminster weaves or fabrics woven on a needle loom, the double thread or filling left by one movement of the needle shall be considered as one shot.

Dissection

14. Samples, in standard condition and which have not been oven-dried, shall be completely picked apart dividing the yarn according to its utility in the carpet, that is pile, warp, stuffer and filling. The debris from the dissection shall be included in the pile yarn weight.

Weights

15. (*a*) The yarns sorted according to their construction purpose shall be weighed under standard conditions.

(*b*) *Pile Yarn.*—The average of the weights of the samples of pile yarn shall be the conditioned weight of pile yarn.

(*c*) *Clean Pile Yarn.*—The average of the weights of the samples of pile yarn, after extraction to remove fats and after desizing to remove sizing materials, shall be the conditioned weight of clean pile yarn.

(*d*) *Warp Yarn.*—The average of the weights of the samples of warp yarn shall be the conditioned weight of warp yarn.

(*e*) *Stuffer Yarn.*—The average of the weights of the samples of stuffer yarn shall be the conditioned weight of stuffer yarn.

(*f*) *Filling Yarn.*—The average of the weights of the samples of filling yarn shall be the conditioned weight of filling yarn.

(*g*) *Weights per Square Yard.*—Each of the conditioned weights of pile, clean pile, warp, stuffer and filling yarn, determined in accordance with Paragraphs (*b*) to (*f*), shall be corrected to the weight per square yard by multiplying by the proper constant and shall be reported as the weight of pile yarn, clean pile yarn, warp yarn, stuffer yarn and filling yarn per square yard, respectively.

(*h*) *Clean Backing Yarns.*—When required, the average of the weights of the samples of warp yarn, stuffer yarn and filling yarn after extractions to remove fats and after desizing to remove size, shall be the conditioned weight of clean warp yarn, clean stuffer yarn and clean filling yarn, respectively.

NOTE.—Methods for desizing and fat removal will be developed and added later.

TENTATIVE METHODS OF TEST
FOR
SMALL AMOUNTS OF COPPER AND MANGANESE IN TEXTILES[1]

A.S.T.M. Designation: D 377 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1933; REVISED, 1936.

Scope

1. These methods of test apply to all textile materials whose content of copper or manganese is less than 0.01 per cent. Two methods are provided for the determination of copper: namely, a volumetric method when the amount of copper is greater than 100 micrograms (1 microgram = 0.001 mg.), and a colorimetric method suitable for use when the amount of copper is less than 100 micrograms. For the determination of manganese a colorimetric method is provided.

Samples

2. The samples for analyses shall be as fairly representative of the material as possible. Each sample shall weigh (preferably) approximately 10 g., but in no case shall the weight be less than 5 g. except for the colorimetric method for copper, in which case the sample shall weigh not less than 1 g.

Blanks

3. Blank tests shall be run on all determinations and deductions made accordingly.

Number of Tests

4. A minimum of three determinations shall be made in every case and the average value taken as the true value. In cases of dispute an average of at least five determinations shall be taken.

Reagents

5. All reagents shall be of c.p. quality as prescribed by the American Chemical Society.

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-13 on Textile Materials.

COPPER DETERMINATION BY VOLUMETRIC METHOD

Solutions Required

6. The following solutions will be required:

(*a*) *Standard Copper Solution.*—Electrolytic copper foil of known purity shall be used for the preparation of the standard solution. The foil shall be cleaned by scraping down to the bright metal. Exactly 1 g. shall be dissolved in an Erlenmeyer flask in the least required amount of a solution of one volume of concentrated HNO_3 to one-half volume of distilled water. Approximately 10 ml. of this diluted acid will be required. After solution, with full use of heat until brown fumes are no longer apparent to the eye, 30 ml. of distilled water and a small amount (approximately 1 g.) of pure powdered talcum shall be added. The mixture shall then be boiled vigorously for at least 10 min. The escaping vapors, when not too strongly acid, may be tested for nitrous acid with moist starch iodide paper. Boiling under these conditions should quickly give a negative test and need not be continued to dryness. After cooling, enough distilled water shall be added to bring the volume up to approximately 100 ml. The talc shall then be filtered off on an asbestos-padded Gooch crucible and washed thoroughly with hot distilled water. The entire filtrate with washings shall be transferred to a 1-liter volumetric flask and, after cooling to 25 C., shall be made up to the mark with distilled water. The strength of this solution may be checked by electrolytic determination of the copper in tartrate-cyanide solution on a platinum dish cathode.[1]

In a volumetric flask, 10 ml. of the standard copper solution shall be diluted to 1 liter with copper-free distilled water at 25 C. One milliliter of this solution is equivalent to 0.00001 g. of copper.

(*b*) *Thiosulfate Solution.*—A solution of sodium thiosulfate of approximately 0.001 *N* strength shall be used. A standard solution of approximately 0.1 *N* strength shall first be prepared by dissolving about 25 g. of the crystalline sodium thiosulfate ($Na_2S_2O_3 \cdot 5H_2O$) and 2 g. of sodium hydroxide in 1 liter of distilled water. In a volumetric flask, 10 ml. of the 0.1 *N* sodium thiosulfate solution shall be diluted to 1 liter with distilled water. The 0.001 *N* sodium thiosulfate solution shall be standardized by taking an amount of the standard copper solution, approximately equivalent to the amount of copper expected in the sample, and treating it as outlined in the determination of copper, starting with the addition of 10 ml. of concentrated HCl, Section 7 (*b*). The 0.001 *N* sodium thiosulfate solution is not very stable and shall be freshly prepared each day from the 0.1 *N* solution.

(*c*) *Starch Indicator Solution.*—This solution shall contain approximately 10 g. of soluble starch per liter of water. The water shall be boiled and the starch dissolved by adding it slowly with rapid stirring to the boiling solution. The starch solution shall be freshly prepared every two to three days.

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[1] A. W. Peters, "A Simple and Rapid Method of Electrolysis of Copper Solutions with Tartrate Cyanide Electrolyte." *Journal*, Am. Chemical Soc., Vol. 34, p. 426 (1912).

(*d*) *Bromine Water*.—The bromine water shall be made by adding an excess of bromine to distilled water, without adding a soluble bromide to increase its concentration. The presence of a soluble bromide leads to the formation of compounds of the nature of hypobromites which will liberate iodine and cause the results to be high.

Method of Analysis

7. (*a*) *Ashing*.—The accurately weighed sample shall be cut into small pieces and placed in a No. 00A porcelain evaporating dish of 10-ml. capacity. The dish shall be placed on a Chromel triangle over a low flame from a bunsen burner protected from strong drafts. Care shall be taken not to allow the material to catch fire. The best condition is after the fiber has distilled off leaving a carbonaceous skeleton. At this point the dish shall be allowed to cool and the residue shall be moistened carefully with five drops of concentrated HNO_3 and one drop of concentrated H_2SO_4. The heat shall again be applied gradually and raised until all carbon and tarry residue is burned off. The time consumed in ashing is usually about 20 min.

(*b*) *Titration*.—The ash shall be dissolved in 10 ml. of concentrated HCl by heating on a hot plate for 10 min. and then transferred to a beaker with 50 ml. of hot distilled water. Approximately 2 to 5 ml. of bromine water shall be added and the solution shall be boiled briskly until the excess bromine has been boiled off. In order to insure the complete removal of the bromine it is necessary to boil the solution down to about one third its original volume. The solution shall be cooled slightly and concentrated NH_4OH added in slight excess. The solution shall then be boiled vigorously for a few minutes in order to coagulate the iron precipitate, expel the excess of ammonia, and destroy compounds which may be formed if all the bromine has not been expelled. The iron precipitate shall be filtered off through a thin asbestos mat and washed three or four times with a little hot distilled water. Dilute acetic acid shall then be added to the filtrate until the blue color just disappears or until the solution is just faintly acid to litmus paper. The solution shall then be heated to boiling for a few minutes more, cooled to tap water temperature, and 5 g. of potassium iodide (free from iodate) or an equivalent amount of a freshly prepared solution of potassium iodide shall be added. One milliliter of starch indicator shall be added and the solution shall be titrated immediately with 0.001 N sodium thiosulfate. It is necessary to stir the solution vigorously when titrating with the 0.001 N solution because diffusion is slower with such a dilute solution. It is advisable to titrate as quickly as possible to the end point. With some samples, if allowed to stand exposed to the air, a blue color will reappear after the titration is completed. This may be disregarded since an end point, permanent for 1 min., indicates that all of the copper has been titrated.

COPPER DETERMINATION BY COLORIMETRIC METHOD

Solutions Required

8. The following solutions will be required:

(*a*) *Standard Copper Solution.*—This solution shall be prepared as described in Section 6 (*a*). One milliliter of this solution is equivalent to 0.00001 g. (10 micrograms) of copper.

(*b*) *Carbamate Reagent.*—This solution shall be prepared by dissolving 1 g. of sodium diethyldithiocarbamate in copper-free distilled water and diluting to 1 liter in a volumetric flask.

Method of Analysis

9. (*a*) *Ashing.*—The sample shall be ashed in accordance with Section 7 (*a*).

(*b*) *Analysis.*—About 10 ml. of concentrated H_2SO_4 shall be added to the ash and the mixture shall be heated on a hot plate for a few minutes, then transferred to an Erlenmeyer flask with about 75 ml. of distilled water. The solution shall be heated to boiling, a few drops of concentrated HNO_3 shall be added and a current of hydrogen sulfide shall be allowed to pass through the solution until it is cold, the flask being closed with a two-hole stopper. After the precipitate has settled, the solution shall be filtered by suction through a small crucible with a porous bottom, washed with water acidified by acetic acid and saturated with hydrogen sulfide until no more iron can be detected in the washings. The crucible shall then be placed by means of a glass triangle over a small crystallizing dish which is on a glass water bath and fuming nitric acid shall be added to the crucible. When no more liquid remains in the crucible, it shall be washed thoroughly with water. The solution in the crystallizing dish shall be evaporated to dryness on the water bath. The crystallizing dish shall then be heated on a hot plate until no more acid fumes are given off. Care shall be taken not to decompose the nitrate. The residue shall be taken up in a small volume of distilled water and diluted to 100 ml. in a volumetric flask.

Colorimetric Comparison

10. (*a*) A 50-ml. aliquot part of the solution (Section 9 (*b*)) shall be pipetted into a 100-ml. Nessler tube to which 10 ml. of the carbamate reagent has been previously added. In a similar tube shall be placed 10 ml. of the carbamate reagent and 40 ml. of distilled water. The standard

copper solution shall be added to the second tube from a burette until the color is almost the same as the tube containing the aliquot part of the sample. The two tubes shall then be made up to the mark with distilled water and the standard copper solution shall be added drop-by-drop to the second tube until it acquires the same color as the first tube. The amount of copper solution used shall be determined. In each of six similar Nessler tubes shall be placed 10 ml. of the carbamate reagent. To the first tube shall be added the exact amount of standard copper solution which was used above; to the second, 0.1 ml. more; to the third, 0.2 ml. more; the fourth, 0.1 ml. less than the first; to the fifth, 0.2 ml. less; and to the sixth, a 50-ml. aliquot part of the sample. The solutions in all the tubes shall be made up to the mark with distilled water. The color of the tube containing the sample shall be matched with the color of one of the standard tubes.

(*b*) If a Duboscq colorimeter is used, the color matching procedure may be considerably shortened. The residue from the evaporation of the nitric acid solution of the sample (Section 9 (*b*)) shall be transferred immediately to one of the colorimeter cups and 10 ml. of the standard copper solution shall be placed in the other cup. Ten milliliters of the carbamate reagent shall be added to each cup and the color compared in the colorimeter. The amount of copper present in the unknown solution shall be calculated from the relative depths of the two solutions.

MANGANESE DETERMINATION BY COLORIMETRIC METHOD

Method of Analysis

11. (*a*) *Ashing.*—The sample shall be ashed in accordance with Section 7 (*a*).

(*b*) *Analysis.*—The ash shall be taken up with a mixture of 15 ml. of 85 per cent phosphoric acid, 5 ml. of concentrated HNO_3 and 20 ml. of distilled water, and transferred to an Erlenmeyer flask. The solution shall be boiled gently for 30 min., then diluted to about 50 ml., filtered, and washed with distilled water. The filtrate shall be diluted to about 100 ml. and 0.5 g. of potassium periodate shall be added, the solution shall be boiled for 1 min., then kept hot for 5 to 10 min. It shall then be cooled, diluted to 100 ml. in a Nessler tube, and compared with a series of color standards (Section 12) of known permanganate content.

Color Standards

12. The color standards of known permanganate content shall be prepared from definite amounts of some pure manganese salt by treatment with phosphoric acid and potassium periodate in the same manner as described in Section 11 (*b*).

TENTATIVE DEFINITIONS AND TERMS RELATING TO TEXTILE MATERIALS[1]

A.S.T.M. Designation: D 123 – 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED AS TENTATIVE, 1921; ADOPTED IN AMENDED FORM, 1927; REVISED, 1930; REISSUED AS TENTATIVE, 1933; REVISED, 1934, 1935, 1936.

Abacá.—See Fibers, Vegetable.

African Sisal.—Under Fibers, Vegetable, see Sisal.

Airplane Fabric (Cotton).—A plain-weave fabric well woven, practically without imperfections, of mercerized two-ply yarns, width 36 to 56 in., maximum weight 4.5 oz. per sq. yd., and threads per inch warp and filling 80 to 84.

Ambari.—Under Fibers, Vegetable, see Kenáf.

Asbestos Roving.—Asbestos roving is composed of a mixture of chrysotile asbestos and cotton or other vegetable fiber.

Reinforced Asbestos Roving.—Reinforced asbestos roving is composed of a core of yarn consisting of vegetable or animal fiber, covered with a mixture of chrysotile asbestos and organic fiber.

Asbestos Yarn.—Yarn consisting of: (1) asbestos fiber; (2) asbestos and vegetable fibers; (3) asbestos and vegetable fibers and wire; or (4) asbestos and vegetable fibers with an insert of cotton or other yarn reinforcement.

Plain Asbestos Yarn.—Yarn consisting of: (1) asbestos fiber, or (2) asbestos and vegetable fibers.

Metallic Asbestos Yarn.—Yarn consisting of plain asbestos yarn twisted with brass, copper or other fine wire. It is also termed "wire-inserted yarn."

Bad Casts (Raw Silk).—Abruptly thickened places on the threads due to the cocoon filament not being properly attached to the thread, or made by adding more than one cocoon filament at a time.

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[1] Under the standardization procedure of the Society, these definitions are under the jurisdiction of the A.S.T.M. Committee D-13 on Textile Materials.

These tentative definitions comprise a revision and combination of the former Standard Definitions of Terms Relating to Textile Materials (A.S.T.M Designation: D 123 – 30) and Tentative Definitions of Terms Relating to Textile Materials (A.S.T.M. Designation: D 123 – 30 T), which definitions were accordingly discontinued in 1933.

Bagging.—A very heavy loosely woven fabric used for bale tares, etc., woven from heavy tight-twisted roving, consisting largely of reworked and waste fibers. Also known as "gunny."

Bahama Sisal.—Under Fibers, Vegetable, see Sisal.

Benares Sunn.—Under Fibers, Vegetable, see Sunn.

Bimlipatam Jute.—Under Fibers, Vegetable, see Kenâf.

Binder Twine.—A somewhat stiff, single strand yarn, 3 to 4 mm. in diameter, made of hard fibers (henequen, sisal, abacá, or phormium), used chiefly for binding bundles of grain, etc.

Boiled-Off Silk.—Silk with the gum (sericin) removed.

Bombay Aloe.—Under Fibers, Vegetable, see Cantara and Piteira.

Book-Fold.—The fabric is doubled selvage to selvage, then folded back and forth upon itself in predetermined lengths. When the piece is completed, the fold-edges on each side are folded to the center and the piece is folded once more upon itself so that the fold-edges are inside, forming a compact package as long as one-half the width of the goods.

Broken Pick.—A streak across the width of the fabric caused by a completely or partially missing pick.

Brown Hemp.—Under Fibers, Vegetable, see Sunn.

Burlap (Jute).—A coarse, heavy, plain-weave fabric of coarse single yarn.

Cable Twist.—A twine, cord, or rope construction in which each successive twist is in the opposite direction to the preceding twist.

Cantala.—See Fibers, Vegetable

Cellulose-Acetate Rayon.—See Fibers, Artificial.

China Grass.—See Fibers, Vegetable.

China Hemp.—Under Fibers, Vegetable, see Hemp.

Chingma.—See Fibers, Vegetable.

Cockled or Cockling.—A curliness or crimpiness appearing in fabrics when different sizes of yarn or varying tensions on the yarns are accidentally introduced.

Coir.—See Fibers, Vegetable.

Cordage Fibers.—See Fibers, Cordage.

Corkscrews (Raw Silk).—A place in the thread in which one or more cocoon filaments are longer than the remainder and give the appearance of a spiral form.

Heavy Corkscrews (Raw Silk).—Corkscrews which are more than twice the diameter of the thread.

Corkscrew Twist.—A place in the yarn or cord where an uneven twist gives a corkscrew-like appearance.

Cotton.—See Fibers, Vegetable.

Crimp.—The difference in distance between two points on a yarn as it lies in a fabric and the same two points when the yarn has been removed from the fabric and straightened, expressed as a percentage of the distance between the two points as the yarn lies in the fabric.

Cuprammonium Rayon.—See Fibers, Artificial.

Cut (Asbestos).—A term indicating the number of an asbestos yarn. The word "cut" preceded by a number indicates, in multiples of 100 yd., the yardage per pound of single-ply yarn. For example, "5 cut" indicates that a pound of single-ply yarn so designated measures approximately 500 yd.; "10 cut" indicates a yarn that measures approximately 1000 yd. per lb.

(Woolen).—See Yarn Number (Woolen—Cut).

Da or Dha.—Under Fibers, Vegetable, see Kenâf.

Daisee Jute.—Under Fibers, Vegetable, see Jute.

Defective Splice.—A splice having irregular final twist, untrimmed ends, or excessive thickness or thinness.

Denier.—A unit of weight (0.05 g.) used to express the number of silk and rayon yarns. The weight in units of 0.05 g. of a 450-m. skein at standard conditions is the denier of silk and rayon (exclusive of spun silk and staple rayon) yarn. It is also equal numerically to the weight in grams of a 9000-m. skein at standard conditions.

Dungaree (Cotton).—A heavy cloth woven in the 2/1 twill weave from dyed warp and filling yarns, in narrow widths, usually 28 in.; approximate number of threads per inch, warp 68 and filling 52; yarn number both warp and filling 20's.

End.—An individual warp yarn.

Felt Jackets.—See Jackets.

Fiber.—A slender, elongated filament, such as rayon, silk, or wool; or a single elongated cell, like cotton or kapok; or a slender strand composed of aggregations of elongated cells like flax, jute and sisal.

Fibers, Artificial:

Cellulose-Acetate Rayon.—Filaments composed of an acetic ester of cellulose which has been coagulated or solidified from its solution.

Cuprammonium Rayon.—Filaments composed of a regenerated cellulose which has been coagulated or solidified from a solution of cellulose in ammoniacal copper oxide.

Nitrocellulose Rayon (Chardonnet).—Filaments composed of a regenerated or denitrated cellulose which has been coagulated or solidified from a solution of nitrated cellulose.

Viscose Rayon.—Filaments composed of a regenerated cellulose which has been coagulated or solidified from a solution of cellulose xanthate.

Fibers, Cordage.—Coarse hard fibers, such as abacá, sisal, henequen, cantala, phormium, palma and piteira (see Fibers, Vegetable), used in the manufacture of ropes and coarse twines. Generally too coarse and stiff to be woven into fabrics.

Fibers, Hard or Leaf.—Rather stiff elongated strands from leaves like sisal, henequen, and piteira (see Fibers, Vegetable), or leaf stems like abacá, used chiefly in coarse twines, ropes and heavy cordage.

Fibers, Soft or Bast.—Flexible elongated strands from the inner bark of plants like flax, hemp, jute and ramie, used in twines, nets and woven fabrics.

Fibers, Textile.—Slender filaments or strands that cling together, enabling them to be spun into yarns of appreciable strength and sufficiently pliable to be woven or knitted into fabrics. Essential requisites are tensile strength, length of at least 5 mm. and more than 100 times the diameter, pliability and cohesiveness; desirable, but not essential, properties are elasticity, fineness, uniformity, durability and luster. Textile fibers include cotton, flax, jute, and many other fibers of vegetable origin; silk, wool and various hairs of animal origin; rayon and allied synthetic or artificial fibers; and asbestos of mineral origin.

Fibers, Vegetable:

Abacá (a-ba-ká).—A hard fiber, rather coarse, firm texture, cream-white to brown in color, 150 to 350 cm. long, strong and durable from the leaf stems forming the trunk of the abacá plant, *Musa textilis*, cultivated in the Philippine Islands, Sumatra, Java and Borneo; used in ropes and coarse twines and cordage, especially marine cordage, oil-well cables, and binder twine. Called "Manila hemp" in the market, but quite unlike true hemp, also called "Cebu hemp" and "Davao hemp."

Cantala.—A hard fiber, finer, softer and weaker than sisal, yellow-white to brownish white, 75 to 150 cm. long, from leaves of the cantala plant, *Agave cantala*, cultivated in the Philippine Islands, Java, Sumatra and India; used in coarse twines including binder twine. Called "Manila maguey" and "Cebu maguey" in market quotations for water-retted, hand-cleaned cantala of the Philippine Islands.

Fibers, Vegetable (Continued):

China Grass.—Ramie fiber separated from the stalk and the thin outer bark, but not degummed; the form in which it is usually exported from China.

Chingma (Ching′-mah).—A rather coarse soft fiber, usually flaggy and fuzzy, straw-white, from the inner bark of the chingma plant, *Abutilon theophrasti*, cultivated in northern China and Japan. Called "China jute" and "Tientsin jute," but it is not a true jute.

Coir.—A hard fiber, usually brown, 10 to 25 cm. long, from the outer husk of the cocoanut, *Cocos nucifera*, produced chiefly in Ceylon and southern India; used in door mats and as a stuffing fiber in upholstery.

Cotton.—Fine, one-celled, twisted fibers, white or in some types tawny, brown or green, 20 to 50 mm. long, growing on the seeds of several different species of the genus *Gossypium*; used more than all other vegetable fibers, and for a wider range of purposes including yarns, twines, woven and knit goods, upholstery stuffing and packing.

American short-staple upland cotton.—Fiber 20 to 27 mm. long, from *Gossypium hirsutum*, cultivated in the southern part of the United States and introduced into nearly all cotton-growing countries.

American long-staple upland cotton.—28 to 40 mm. long, from selected varieties of *Gossypium hirsutum*, cultivated largely in the Yazoo-Mississippi delta. Also called "delta cotton."

Arizona Egyptian cotton.—Fiber 35 to 45 mm. long, from modified forms of *Gossypium barbadense*, cultivated in Arizona and southern California, includes "Pima cotton."

Egyptian cotton.—Fiber 30 to 40 mm. long, white or in some varieties light brown, from modified forms of *Gossypium barbadense*, cultivated chiefly in lower Egypt, includes "Sakellarides," "Zagora," etc.

India cotton.—Short staple, 18 to 25 mm. long, from *Gossypium neglectum*, cultivated in India.

Levant cotton.—Short staple, 18 to 25 mm. long, from *Gossypium herbaceum*, cultivated in Asia Minor and countries bordering the Mediterranean Sea.

Fibers, Vegetable (Continued):

Rough Peruvian cotton.—A rather harsh, wiry cotton, from *Gossypium peruvianum*, cultivated in Peru, used chiefly for mixing with wool.

Sea island cotton.—Fine fiber, 30 to 50 mm. long, from *Gossypium barbadense*, cultivated chiefly in the West Indies, used in the finest cotton yarns.

Flax.—A soft, fine fiber, dark gray, bluish green, brown or cream white, 40 to 100 cm. long, from the inner bark of the fiber flax plant, *Linum usitatissimum*, cultivated chiefly in northern Europe; used in linen thread, shoe thread, seine twine, sacking twine, laces, table linen, handkerchiefs, towels and in all true linens.

Courtrai flax.—Flax fiber of superior quality, very carefully prepared from straw retted in the River Lys, or most of it in recent years tank-retted in the vicinity of Courtrai, Belgium.

Dew-retted flax (Slanetz of Russia).—Flax fiber prepared by spreading the plants on the ground and exposing to the weather for retting.

Flax tow.—Short or tangled fiber beaten out in scutching—often called scutching tow; or combed out in hackling and called machine tow; used in flax yarns and twines. (This flax tow is distinctly different from upholstery flax tow.)

Flemish flax.—Flax produced in Flanders (northeastern France and Belgium).

Hackled flax (also called "dressed flax" or "dressed line").—Flax fiber, which after being scutched, has been cleaned further by combing over hackles.

Irish flax.—Flax fiber produced in northern Ireland, mostly retted in bogs, yielding a very strong fiber.

Risten (*R* in market quotations).—The standard grade of flax on which other grades of the Baltic countries are based.

Water-retted flax (Motchenetz of Russia).—Flax fiber, light cream-white to gray in color, prepared by retting the plants in water.

Fibers, Vegetable (Continued):

Hemp.—A soft fiber, dark steel gray to cream-white, usually in narrow flat ribbons, 100 to 250 cm. long, from the inner bark of the hemp plant, *Cannabis sativa*, cultivated in Italy, Soviet Republic, Yugoslavia, Hungary, China, Japan, Chile, Wisconsin, Illinois and Kentucky; used in America in commercial twines, marlines, halyards and tarred rigging.

Hemp line.—Hemp fiber, scutched and prepared so that the fibers lie straight and parallel.

Hemp tow.—Short or tangled hemp fiber, beaten out in scutching the long fiber, or hemp fiber produced from short or tangled stalks.

Italian hemp.—Hemp fiber produced in Italy, mostly water-retted and well prepared and graded.

Kentucky rough prime.—The best quality of Kentucky dew-retted hemp, broken on hand brakes, but not hackled.

Kentucky single-dressed.—Kentucky hemp further prepared by drawing it over a coarse hackle.

Russian hemp.—Hemp fiber chiefly dew-retted and prepared by hand in the Soviet Republic.

Wisconsin hemp.—Hemp fiber produced in Wisconsin by dew-retting and breaking and scutching by machinery.

Henequen (hen-e-ken′).—A hard fiber, rather coarse, of firm texture, light yellow or sometimes reddish yellow, cylindrical, 75 to 150 cm. long, from the leaves of the henequen plant, *Agave fourcroydos*, cultivated in the Yucatan peninsula, and in Tamaulipas in Mexico and in Cuba; used chiefly in binder twine and in other coarse twines and small ropes.

Istle (eest′-ley).—Hard fibers, light yellow, 20 to 50 cm. long, cylindrical and stiff, from the leaves of two closely related species of *Agave*, growing without cultivation in Mexico, used chiefly in brushes, and to a less extent in twines; used in Mexico for handmade twines and coarse sacks. Also called "Tampico" and "Mexican Fiber."

Jute.—Soft fibers, light yellow to nearly white or bright copper to deep slate, changing in age to dingy brown or gray, 100 to 500 cm. long, averaging about 240 cm. exclusive of butts.

Fibers, Vegetable (Continued):

Jute (Continued):

from the inner bark of the round-pod jute, *Corchorus capsularis*, and the long-pod jute, *Corchorus olitorius*, cultivated in India, chiefly in Bengal, and to a very limited extent elsewhere in southern Asia and in tropical Africa; used in twines, gunnies, burlaps, hessians, carpet yarns, sacks for sugar, coffee, grain, feed, fertilizer and wool, and backing for linoleum and oilcloths.

Jute butts.—The flaggy lower ends of jute fiber, 10 to 25 cm. long, cut off in preparing jute for market, used in twines and coarse bagging, especially in covering for bales of cotton.

Daisee jute (also spelled *desi* and *deshi*, meaning "local").—Fiber of long-pod jute, *Corchorus olitorius*, grown in the brackish soils in the region of Calcutta, generally ranging from copper brown to slate gray.

Tossa jute.—Fiber of long-pod jute, *Corchorus olitorius*, grown on uplands in eastern India; pearl gray to deep slate color or copper brown.

Kapok.—Stuffing fiber, composed of single cells 20 to 30 mm. long, white gray or tawny in color, produced in the seed pods of the kapok tree, *Ceiba pentandra*, and closely allied species of the bombax family, resistant to the absorption of moisture, resilient and buoyant; used as stuffing in pillows, mattresses and life preservers and for temperature and sound insulation.

Kenâf.—A soft jute-like fiber, light yellow to gray, flaggy at base, 150 to 250 cm. long, from the inner bark of the kenâf plant, *Hibiscus cannabinus*, cultivated most extensively in Persia and Trans-Caspian Russia. Called "Da" in French West Africa, "Gombo" in Portuguese Africa, "Ambari" and "Deccan Hemp" in India, "Bimlipatam" in Madras Presidency; used in twines and for purposes similar to jute.

Mescal Maguey.—A hard fiber, light straw-yellow, slightly finer and softer than sisal, 80 to 150 cm. long, from leaves of the mescal maguey plant, *Agave pseudotequilana*, cultivated in western Mexico; used in twines and cordage.

Fibers, Vegetable (Continued):

Palma.—A hard fiber nearly white or light brownish yellow, often with some coarser dark brown curved ends, 25 to 50 cm. long, from the leaves of a tree yucca, *Samuela carnerosana*, growing on high mountains in northern Mexico; used for twines, especially "paper twines." Also called "palma istle," but quite unlike istle fibers.

Phormium (for′-mi-um).—A hard fiber, reddish yellow or nearly white, finer and softer than abacá, 150 to 300 cm. long, from the leaves of the harakeke lily, *Phormium tenax*, growing wild and cultivated in New Zealand, and cultivated in St. Helena; used chiefly in hard fiber twines, including binder twine. Called "New Zealand hemp" and "New Zealand flax" but the fiber is unlike hemp or flax.

Piteira (pe-ter′-a).—A hard fiber, nearly white, and finer and softer than other hard fibers as it is prepared in Mauritius, 150 to 250 cm. long, from the leaves of the giant cabuya, *Furcraea gigantea*, native in eastern Brazil and cultivated in Mauritius, India and Natal; used chiefly for mixing with other fibers to improve the color of ropes. Called "Mauritius hemp," but it is not a true hemp and is produced in other countries besides Mauritius.

Ramie.—A soft fiber, parchment-like, light yellow or greenish and stiff in the form called "China grass," white, soft and slightly coarser than flax when degummed and bleached, very strong and durable, from the inner bark of the ramie plant, *Boehmeria nivea*, cultivated in China and Japan; used in China for dress goods and "grass cloth," in Japan for seine twine and mosquito nets and in Germany for shoe thread, trimmings, tapestries, and various woven fabrics. Also called "rhea."

Sisal.—A hard fiber, of firm texture, light yellow or nearly white sometimes slightly green, very strong and durable, 100 to 180 cm. long, from the leaves of the sisal plant, *Agave sisalana*, native in Yucatan, cultivated in East Africa, Java, Sumatra, Haiti and the Bahamas; used in hard fiber twines including binder twine and also in coarse cordage.

Bahama Sisal.—Retted in sea water and cleaned by hand; is finer, softer, weaker and lacking in luster.

Fibers, Vegetable (Continued):

Sunn.—A soft fiber, gray or brown with a wide range of color and quality due to differences in preparation, 50 to 150 cm. long, from the inner bark of the sunn plant, *Crotalaria juncea*, cultivated in India; used in twines. Also called "Sunn hemp," "India hemp," "Bombay hemp," "Brown hemp," and various sorts by the names "Benares," "Itarsi," "Jubbulpore," "Madras" and "Sewnee."

Filament.—A fine fiber or fibril.

Flax.—See Fibers, Vegetable.

Float (Defect).—A place in the fabric where warp or filling threads extend unbound over threads with which they should be interlaced.

Gage.—A measure of the fineness of knit fabric as determined by the closeness of the wales, that is, the longitudinal rows of loops. It is expressed by the number of wales or needles in one and one half inches.

NOTE.—The word "gage" is also used as an expression of thickness.

Gombo Hemp.—Under Fibers, Vegetable, see Kenáf.

Grenadine Yarn (Silk).—A yarn composed of more than one strand, each individual strand of which has been doubled with a reverse twist, each twist having a minimum of approximately the following number of turns per inch depending on the number of strands used:

STRANDS	MINIMUM NUMBER OF TURNS
2 ($\frac{13}{15}$ denier or equivalent)	32
3	30
4	28

NOTE.—When more than 4 strands are used, the minimum number of turns is decreased in accordance with the above proportion.

Hairiness (Raw Silk).—The condition of the thread when there are numerous loose ends of cocoon filaments projecting from the thread.

Hawser Twist (Cotton).—A twine, cord or rope construction in which the first and second twists are in the same direction and the third twist in the opposite direction.

Heavy Corkscrews.—See Corkscrews.

Heavy Goods.—Name applied in Calcutta quotations to material called "sacking" in the United States.

Hemp.—See Fibers, Vegetable.

Henequen.—See Fibers, Vegetable.

Hessians.—Name applied in United Kingdom, India, and on the Continent to material called "burlap" in the United States.

Holland Finish (Cotton).—A glazed or unglazed finish, consisting of oil and a filling material, applied to cotton fabrics to make them opaque or semi-opaque; resembles a beetled linen fabric formerly known as "Holland."

Indian Hemp.—Under Fibers, Vegetable, see Sunn.

Istle.—See Fibers, Vegetable.

Italian Hemp.—Under Fibers, Vegetable, see Hemp.

Jackets (woven or felted).—A textile product, woven or pressed into tubular or sleeve form, ready for covering and shrinking on a machine roll.

Jubbulpore Hemp.—Under Fibers, Vegetable, see Sunn.

Jute.—See Fibers, Vegetable.

Jute Butts.—See Fibers, Vegetable.

Kapok.—See Fibers, Vegetable.

Kenâf.—See Fibers, Vegetable.

Kink (fabric).—A place in the fabric where a slack strand has twisted on itself, forming a loop in the yarn or cord.

Knot.—A joining by tying of threads together.

Long Knots (Raw Silk).—Knots which have loose ends from 3 to 25 mm. ($\frac{1}{8}$ to 1 in.) in length.

Very Long Knots (Raw Silk).—Knots which have loose ends exceeding 25 mm. (1 in.) in length.

Laid Fabric (Cotton).—A fabric made without filling yarn, the parallel warp yarns being held together by means of rubber latex or other binding material.

Lea (Cotton).—A 120-yd. skein of yarn containing 80 turns, that is, each 1$\frac{1}{2}$ yd. in length.

(Linen).—See Yarn Number (Linen).

Linen.—Under Fibers, Vegetable, see Flax.

Loop-Knot.—A snarl or curl produced by a filling yarn coiling upon itself.

Loops (Raw Silk).—Small open places in the thread due to the excessive length of one or more cocoon filaments.

Long Loops.—Loops which exceed 1 cm. ($\frac{1}{2}$ in.) in length.

Long Knot.—See Knot.

Maguey.—Under Fibers, Vegetable, see Cantala and Mescal Maguey.

Manila Hemp.—Under Fibers, Vegetable, see Abacá.

Mauritius Hemp.—Under Fibers, Vegetable, see Piteira.

Mescal Maguey.—See Fibers, Vegetable.

Metallic Asbestos Yarn.—See Asbestos Yarn.

Mexican Fiber.—Under Fibers, Vegetable, see Istle.

Mexican Sisal.—Under Fibers, Vegetable, see Henequen.

Mispick.—A pick not properly interlaced.

Moisture Content (Moisture, Percentage of Moisture).—The moisture present in a textile material expressed as a percentage of the original weight as determined by definite prescribed methods.

Moisture-Free Weight.—The weight of a textile material determined after drying to constant weight by definite prescribed methods.

Moisture Regain.—The moisture present in a textile material expressed as a percentage of the moisture-free weight, as determined by definite prescribed methods.

Natal Hemp.—Under Fibers, Vegetable, see Piteira.

Neatness (Raw Silk).—An expression of the degree of freedom of the raw silk thread from loops, nibs, and hairiness as defined.

New Zealand Flax.—Under Fibers, Vegetable, see Phormium.

Nibs (Raw Silk).—Small thickened places less than 3 mm. ($\frac{1}{8}$ in.) in length.

Nitrocellulose Rayon.—See Fibers, Artificial.

Number of Yarn.—See Yarn Number.

Off-Square.—The difference between the percentage of warp crimp and the percentage of filling crimp.

Organzine Yarn.—Two or more raw silk strands twisted in the singles, doubled and twisted in the reverse direction in the ply. Turns per inch in the singles and ply usually within the limits of 10 to 20 turns; generally used as warp.

Palma.—See Fibers, Vegetable.

Philippine Maguey.—Under Fibers, Vegetable, see Cantala.

Phormium.—See Fibers, Vegetable.

Pick.—An individual filling yarn.

Piteira.—See Fibers, Vegetable.

Plain Weave.—A fabric pattern in which each yarn of the filling passes alternately over and under a yarn of warp and each yarn of the warp passes alternately over and under a yarn of the filling.

Ramie.—See Fibers, Vegetable.

Raw Silk.—Silk as it has been reeled from the cocoon.

Rayon.—A generic term for filaments made from various solutions of modified cellulose by pressing or drawing the cellulose solution through an orifice, and solidifying it in the form of a filament.

NOTE.—Rayon as commercially manufactured is produced by four different processes. The resulting rayons from each process while similar in appearance differ amongst themselves and with each other to a more or less degree according to the differences in their physical and chemical properties. The different type rayons are known as follows:

(*a*) Nitrocellulose Rayon (Chardonnet)
(*b*) Viscose Rayon
(*c*) Cuprammonium Rayon
(*d*) Cellulose-Acetate Rayon

Reed Marks.—Marks or lines warpwise of the cloth, usually caused by too many or too few warp yarns being drawn into a dent, a faulty setting of the loom, or imperfections in the reed.

Regain.—See Moisture Regain.

Reinforced Asbestos Roving.—See Asbestos Roving

Run (Woolen).—See Yarn Number (Woolen Run).

Russian Hemp.—Under Fibers, Vegetable, see Hemp.

Sewed Yarn.—A yarn in the fabric interwoven by hand.

Shoe-Fold.—The fabric is folded from both ends into twelve or sixteen folds to the piece, the length of the fold depending upon the length of the piece.

Sisal.—See Fibers, Vegetable.

Size.—See Yarn Number.

Slub.—See Slug (General).

Slug (Raw Silk).—A thickened place several times the diameter of the thread, 3 mm. ($\frac{1}{8}$ in.) or over in length.

Long or Large Slug (Raw Silk).—A slug which exceeds 1 cm. ($\frac{1}{2}$ in.) in length or which is very much larger in diameter than the thread.

(General).—An abruptly thickened place in the yarn or a bunch of lint entangled in the yarn, cord, or fabric.

Smash.—A place in the fabric where a number of warp yarns or cords have been broken, usually due to the shuttle getting caught in the shed during weaving, or to faulty harness motion.

Spun Rayon.—Yarn made from cut rayon filaments, the cut filaments being twisted and drawn out into a yarn by usual spinning processes.

Spun Silk.—Silk yarn consisting of short filaments obtained from silk wastes spun in a similar manner to worsted yarn.

Standard Atmosphere (Textiles).—Air maintained at a relative humidity of 65 per cent at 70 F.

Standard Moisture Regain.—An arbitrary figure formally adopted for the regain of any specific textile material to be used in calculating the standard weights of shipments or deliveries of textiles.

Standard Weight.—The moisture-free weight of a textile material plus the weight corresponding to its standard moisture regain.

Sunn.—See Fibers, Vegetable.

Tampico Fiber.—Under Fibers, Vegetable, see Istle.

Thick and Thin Places (Major Defects).—Places in the fabric where for 1 in. or more the count varies more than a specified percentage from the specified count.

(Minor Defects).—Places in the fabric where for less than 1 in. the count varies more than a specified percentage from the specified count.

Thread (Silk).—The ply of yarns is sometimes referred to as the number of thread, as 2 thread for a 2 ply.

Thrown Silk.—Raw silk that has been twisted, or doubled and twisted.

Tientsin Jute.—Under Fibers, Vegetable, see Chingma.

Tire Builder Fabric.—A fabric consisting of hawser cord yarn in the warp with single yarn filling at intervals to keep the warp threads together.

Tossa Jute.—Under Fibers, Vegetable, see Jute.

Tram Yarn (Silk).—Raw silk threads doubled and twisted with a low number of turns per inch, generally used as filling.

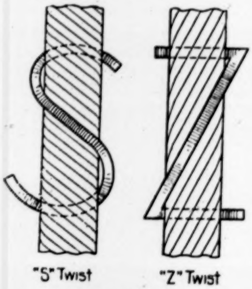
Tula Istle.—Under Fibers, Vegetable, see Istle.

Twill Weave.—A weave which produces pronounced lines running diagonally across the fabric.

Warp Face Twill.—A twill weave in which the warp threads produce the diagonal effect.

Twine (Not Binder Twine).—A cord made up of two or more yarns of medium twist with ply twist in the opposite direction.

Twist, Direction of.—A yarn or cord has **S** twist if, when held in a vertical position, the spirals conform in slope to the central portion of the letter "S," and **Z** twist if the spirals conform in slope to the central portion of the letter "Z."



Viscose Rayon.—See Fibers, Artificial.

Webbing, Elastic.—A strong narrow fabric made with rubber threads as part of warp or filling or of both.

Wrong Draw.—A defect in a fabric due to the warp and filling not interlacing in accordance with the prescribed weave or design and caused when one or more warp yarns have been drawn through the wrong harness.

Yarn.—An assemblage of fibers or filaments of animal, mineral, or vegetable origin, alone or in combination, either natural or manufactured, twisted or laid together to form a strand or group of strands for use in weaving, knitting, or forming in any manner into textile materials.

Yarn Number (Asbestos).—See Cut (Asbestos).

(Cotton).—The number of 840-yd. hanks contained in 1 lb. avoirdupois (7000 grains) of the yarn at standard conditions. The number of folded or plied yarns is that of the single yarn from which they are spun.

(Jute).—The weight in pounds of a spindle of 14,400 yd. of yarn at standard conditions expressed as "pounds per spindle."

(Linen).—The number of 300-yd. hanks contained in 1 lb. avoirdupois (7000 grains) of the yarn at standard conditions. The number of folded or plied yarns is that of the single yarn from which they are spun. Also known as "lea."

(Raw Silk).—See Denier.

(Rayon).—See Denier.

(Spun Rayon).—The number of 840-yd. hanks contained in 1 lb. avoirdupois (7000 grains) of the yarn at standard conditions. The number of folded or plied yarns is that of the single yarn from which they are spun.

(Spun Silk).—The number of 840-yd. hanks contained in 1 lb. avoirdupois (7000 grains) of the yarn at standard conditions. The number of folded or plied yarns is that of the finished yarn.

(Woolen—Cut).—The number of 300-yd. "cuts" or hanks in 1 lb. avoirdupois (7000 grains) of the yarn at standard conditions.

(Woolen—Run).—The number of 1600-yd. hanks in 1 lb. avoirdupois (7000 grains) of the yarn at standard conditions.

(Woolen and Worsted—Typp System).—The number of a woolen or worsted yarn shall be the number of thousands of yards per pound.

(Worsted).—The number of 560-yd. hanks in 1 lb. avoirdupois (7000 grains) of the yarn at standard conditions. The number of folded or plied yarns is that of the single yarn from which they are spun.

Yarn Size.—See Yarn Number.

TENTATIVE METHOD OF TEST

FOR

SOFTENING POINT BY RING-AND-BALL APPARATUS[1]

A.S.T.M. Designation: E 28 - 36 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1936.[2]

Scope

1. (*a*) This method of test for softening point by ring-and-ball method is applicable to asphalts, tars, pitches, rosins and most resins both natural and synthetic.

(*b*) *Softening Point.*—In general, with materials of this type, softening does not take place at a definite temperature. As the temperature rises, these materials gradually and imperceptibly change from brittle or exceedingly thick and slow flowing materials to softer and less viscous liquids. For this reason the determination of the softening point must be made by a fixed, arbitrary and closely defined method if the results obtained are to be comparable.

Apparatus

2. The apparatus shall consist of the following:

(*a*) *Ring.*—A brass ring of the following dimensions:

	MILLIMETERS	INCHES	TOLERANCES, MM.
Depth	6.35	$\frac{1}{4}$	±0.10
Inside diameter at bottom	15.88	$\frac{5}{8}$	±0.10
Inside diameter at top	17.46	$\frac{11}{16}$	±0.10
Outside diameter	20.60[a]	$\frac{13}{16}$	±0.10

[a] For convenience in mounting (see Fig. 2), the outside diameter of the ring at the bottom may be smaller but not less than 18.0 mm. (0.71 in.).

The ring may be attached, by brazing, to a No. 11 B. & S. gage brass wire (diameter 2.31 mm. = 0.091 in.), (see Fig. 1).

(*b*) *Ball.*—A steel ball, 9.53 mm. ($\frac{3}{8}$ in.) in diameter weighing between 3.45 and 3.55 g.

(*c*) *Ball Guide.*—A ball guide for centering the balls, constructed of brass, and having the shape and dimensions illustrated in Fig. 2.

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee E-1 on Methods of Testing.

The ring-and-ball method was first standardized by the Society's Committee D-4 on Road and Paving Materials as applying to bituminous materials and issued under the A.S.T.M. Designation D 36. The present method is an extension and modification of the ring-and-ball method to make it applicable to materials other than bituminous materials as well.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 26, 1936.

(*d*) *Container.*—A glass vessel, capable of being heated, not less than 8.5 cm. ($3\frac{1}{3}$ in.) in diameter and not less than 10.5 cm. ($4\frac{1}{8}$ in.) in depth from the bottom of the flare. (A 600-ml. low form Griffin beaker meets this requirement. For use with the ring holder an 800-ml. tall form beaker is convenient.)

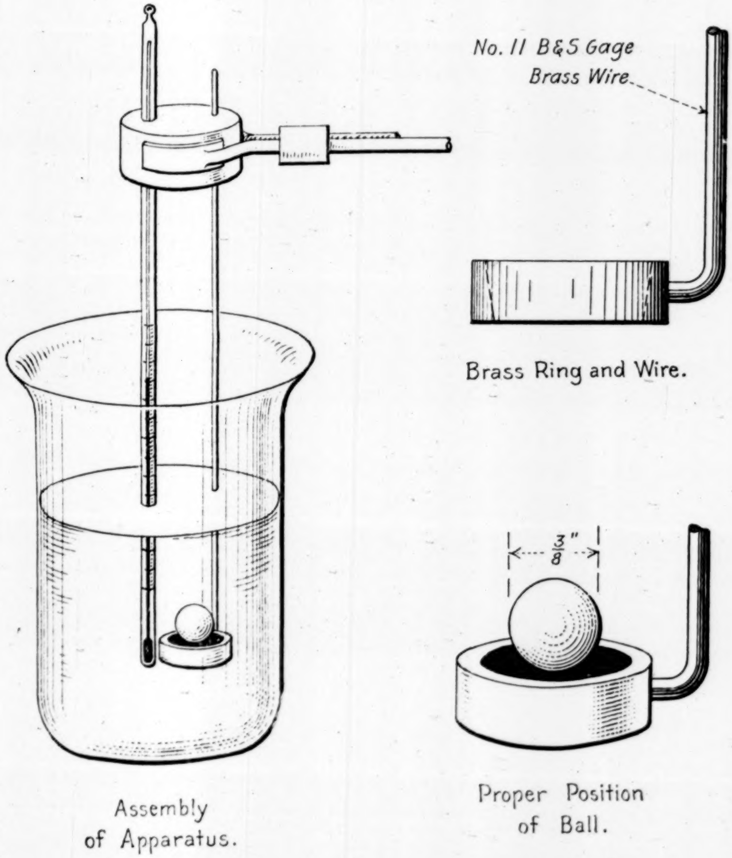

FIG. 1.—Assembly of Apparatus, Showing Single Ring.

(*e*) *Support for Ring and Thermometer.*—Any convenient method for supporting the ring and thermometer may be used (see Figs. 1, 3 and 4) providing it meets the following requirements: The ring shall be supported in a substantially horizontal position. The top of the ring shall be at least 7.6 cm. (3.0 in.) below the top of the container and at least 5.1 cm. (2.0 in.) below the surface of the heating liquid. Using the apparatus in Fig. 1, the bottom of the ring shall be 2.5 cm. (1.0 in.) above the bottom of the glass vessel. If the ring holder is used (see Fig. 3), the bottom of the ring shall be 2.5 cm. (1.0 in.) above the upper surface of the lower horizontal plate; the lower horizontal plate shall be at least 1.3 cm. ($\frac{1}{2}$ in.) above the bottom of the glass vessel. The thermometer shall be suspended so that the bottom of the bulb is level with the bottom of the ring and within 1.0 cm. ($\frac{3}{8}$ in.) but not touching the ring. For referee work the ring holder shall not carry more than two rings.

(*f*) *Thermometers.*—(*1*) The A.S.T.M. Low S. P. Thermometer shall conform to the following requirements. These specifications cover a special

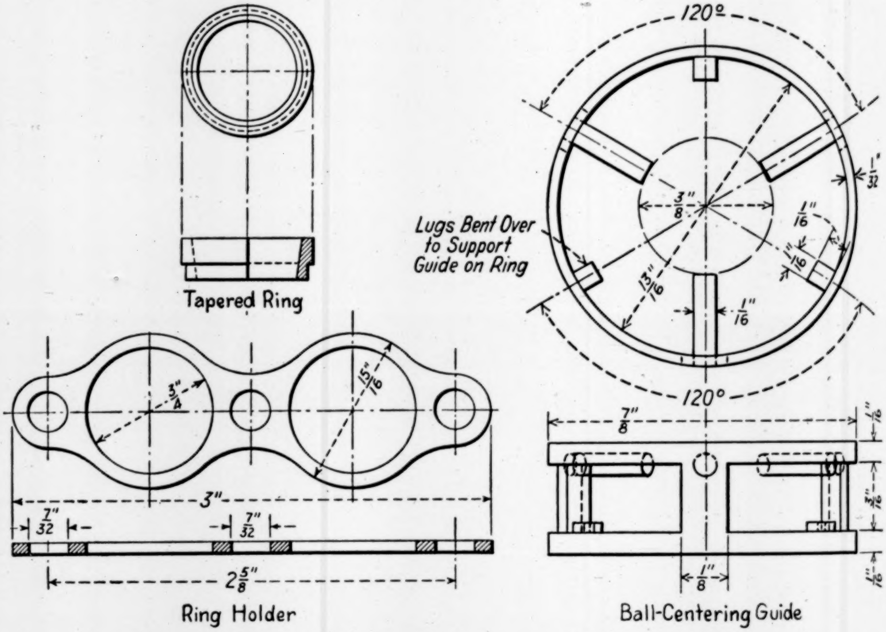
120°
Tapered Ring
Lugs Bent Over to Support Guide on Ring
3/8"
1/16"
1/32"
1/16"
13/16"
1/16"
120°
3/4"
15/16"
3"
7/32"
7/32"
2 5/8"
Ring Holder
7/8"
1/16"
3/16"
1/16"
1/8"
Ball-Centering Guide

FIG. 2.—Tapered Ring, Ball Centering Guide and Ring Holder.

thermometer graduated in either Centigrade or Fahrenheit degrees, as specified, the ranges being –2 to +80 C. or +30 to +180 F., respectively.

TYPE: Etched stem, glass.
LIQUID: Mercury.
RANGE AND SUBDIVISION: –2 to +80 C. in 0.2 C. or +30 to +180 F. in 0.5 F.
TOTAL LENGTH: 378 to 384 mm. (14.88 to 15.12 in.).
STEM: Plain front, enamel back, suitable thermometer tubing. Diameter, 6.0 to 7.0 mm. (0.24 to 0.28 in.).
BULB: Corning normal or equally suitable thermometric glass.
Length, 9 to 14 mm. (0.35 to 0.55 in.).
Diameter, 4.5 to 5.5 mm. (0.18 to 0.22 in.).
DISTANCE TO 0 C. OR 32 F. LINE FROM BOTTOM OF BULB: 75 to 90 mm. (2.95 to 3.54 in.).
DISTANCE TO 80 C. OR 176 F. LINE FROM TOP OF THERMOMETER: 30 to 45 mm. (1.18 to 1.77 in.).

EXPANSION CHAMBER: To permit heating the thermometer at least 50 C. (90 F.) above highest temperature on scale.

FILLING ABOVE MERCURY: Nitrogen gas.

TOP FINISH: Glass Ring.

GRADUATION: All lines, figures, and letters clear cut and distinct. Each whole degree Centigrade or Fahrenheit line to be longer than the remaining lines. Graduations to be numbered at each multiple of 2 C. or 5 F.

IMMERSION: Total.

SPECIAL MARKING: "A.S.T.M. Low S.P.," a serial number and the manufacturer's name or trade mark shall be etched on the thermometer.

SCALE ERROR: The error at any point of the scale when the thermometer is standardized as provided below shall not exceed 0.2 C. or 0.4 F.

STANDARDIZATION: The thermometer shall be standardized immersed in the testing bath to the top of the mercury column, at the ice point and at temperature intervals of approximately 20 C. or 40 F.

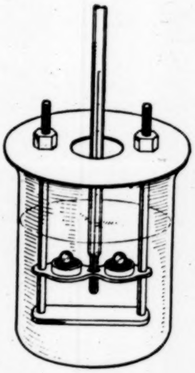

FIG. 3.—Assembly of Apparatus, Showing Two Rings.

CASE: The thermometer shall be supplied in a suitable case on which shall appear the marking: "A.S.T.M. Low S.P., −2 to +80 C.," or "A.S.T.M. Low S.P., +30 to +180 F." according to the type of thermometer.

NOTE.—For the purpose of interpreting these specifications the following definitions apply:

The total length is the over-all length of the finished instrument.

The diameter is that measured with a ring gage.

The length of the bulb is the distance from the bottom of the bulb to the beginning of the enamel backing.

The top of the thermometer is the top of the finished instrument.

(*2*) The A.S.T.M. High S. P. Thermometer shall conform to the following requirements. These specifications cover a special thermometer graduated in either Centigrade or Fahrenheit degrees, as specified, the ranges being 30 to 200 C. or 85 to 392 F., respectively.

TYPE: Etched stem, glass.

LIQUID: Mercury.

RANGE AND SUBDIVISION: 30 to 200 C. in 0.5 C. or 85 to 392 F. in 1 F.

TOTAL LENGTH: 378 to 384 mm. (14.88 to 15.12 in.).

STEM: Plain front, enamel back, suitable thermometer tubing.
Diameter, 6.0 to 7.0 mm. (0.24 to 0.28 in.).

BULB: Corning normal or equally suitable thermometric glass.
Length, 9 to 14 mm. (0.35 to 0.55 in.).
Diameter, 4.5 to 5.5 mm. (0.18 to 0.22 in.).

DISTANCE TO 30 C. OR 85 F. LINE FROM BOTTOM OF BULB: 75 to 90 mm. (2.95 to 3.54 in.).

DISTANCE TO 200 C. OR 392 F. LINE FROM TOP OF THERMOMETER: 30 to 45 mm. (1.18 to 1.77 in.).

EXPANSION CHAMBER: To permit heating the thermometer at least 50 C. (90 F.) above the highest temperature on the scale.

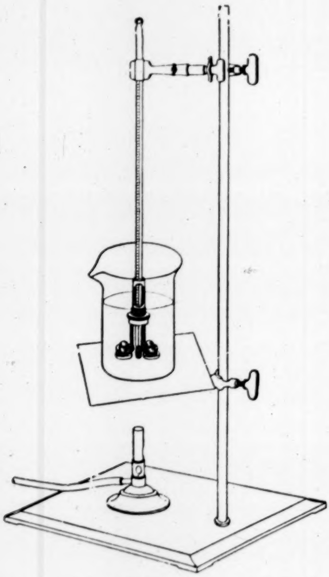

FIG. 4.—Assembly of Apparatus, Showing Four Rings.

FILLING ABOVE MERCURY: Nitrogen gas.

TOP FINISH: Glass ring.

GRADUATION: All lines, figures, and letters clear cut and distinct. Each whole degree Centigrade line or the first and each succeeding 5 F. line to be longer than the remaining lines. Graduations to be numbered at each multiple of 5 C. or 10 F.

IMMERSION: Total.

SPECIAL MARKING: "A.S.T.M. High S.P.," a serial number and the manufacturer's name or trade mark shall be etched on the thermometer.

SCALE ERROR: The error at any point of the scale when the thermometer is standardized as provided below shall not exceed 0.3 C. or 0.5 F.

STANDARDIZATION: The thermometer shall be standardized, immersed in the testing bath to the top of the mercury column, at intervals of approximately 40 C. or 70 F.

CASE: The thermometer shall be supplied in a suitable case on which shall appear the marking: "A.S.T.M. High S.P., 30 to 200 C.," or "A.S.T.M. High S.P., 85 to 392 F." according to the type of thermometer.

NOTE.—For the purpose of interpreting these specifications the following definitions apply:

The total length is the over-all length of the finished instrument.
The diameter is that measured with a ring gage.
The length of the bulb is the distance from the bottom of the bulb to the beginning of the enamel backing.
The top of the thermometer is the top of the finished instrument.

Preparation of Sample

3. The sample shall be selected from the material to be tested in such a manner as will avoid the inclusion of the surface layer and a quantity at least twice that necessary to fill the desired number of rings and in no case less than 40 g. shall be melted immediately in a clean container, using an oven, sand or oil bath to prevent local overheating. Care shall be taken to avoid incorporating air bubbles in the sample which should not be heated more than 30 C. (54 F.) above its softening point, in the case of materials having a softening point below 121 C. (250 F.), except rosin, or more than 50 C. (90 F.) for rosin and materials with softening points above 121 C. (250 F.), for materials having a long softening range it may be necessary to increase this to 85 C. (185 F.), the time from the beignning of heating to the pouring of the sample not to exceed 15 min. Immediately before filling the rings, they shall be preheated to approximately the temperature at which the material is to be poured. The rings, while being filled, should rest on an amalgamated brass plate. The quantity of material poured into the rings shall be such that after 20-min. cooling at room temperature of materials with softening points below 80 C. (176 F.) and 40-min. cooling for materials of higher softening point, an excess amount will remain which shall then be cut off cleanly with a slightly heated spatula. For routine testing this period of time may be curtailed according to the characteristics of the material under test. In case the test is to be repeated, a clean container and fresh sample shall be used.

Procedure

4. (*a*) *Assembling Apparatus.*—The glass container shall be filled to a depth not less than 9 cm. (3.5 in.) with freshly boiled distilled water (or with glycerin for materials melting above 80 C. (176 F.)) which has been cooled to not less than 45 C. (81 F.) below the anticipated softening point but in no case lower than 5 C. (41 F.) for materials melting below 80 C. (176 F.) and in no case lower than 35 C. (95 F.) for materials melting above 80 C. (176 F.). The ring containing the sample and ball guide shall be suspended in the water so that the lower surface of the filled ring is 2.5 cm. (1 in.) above the bottom of the glass container (Fig. 1) or 2.5 cm. above the upper surface of the lower horizontal plate which is at least 1.3 cm. (½ in.) above the bottom of the glass vessel (Fig. 3) and so that its upper

surface is at least 5.1 cm. (2 in.) below the surface of the water. The ball shall be placed in the water but not on the specimen. The thermometer shall be suspended so that the bottom of the bulb is level with the bottom of the ring and within 1.0 cm. ($\frac{3}{8}$ in.) but not touching the ring. The initial temperature shall be maintained for 15 min. With suitable forceps the ball shall be placed in the center of the upper surface of the material in the ring, using the ball guide to hold the ball in this position.

(*b*) *Heating.*—To facilitate uniform heating, the burner shall be placed midway between the center and the edge of the beaker on a diameter at right angles to the diameter which includes the ring or rings and the thermometer bulb. The effect of drafts on uniformity of heating must be eliminated, using shields if necessary. The heat shall be applied in such manner that the temperature of the bath is raised 5 C. (9 F.) each minute.

(*c*) *Permissible Variation in Rise of Temperature.*—The rate of rise of temperature shall be uniform and shall not be averaged over the period of the test. The maximum permissible variation for any minute period after the first three shall be ±0.5 C. (±0.9 F.). All tests in which the rate of rise exceeds these limits shall be rejected.

Softening Point

5. The temperature reading to one-half of the smallest scale division indicated by the thermometer at the instant the sample touches the bottom of the container (or the lower horizontal plate) shall be taken as the softening point. No corrections shall be made for emergent stem.

Precautions

6. (*a*) The use of freshly boiled distilled water is essential, as otherwise air bubbles may form on the specimen and affect the results. Rigid adherence to the prescribed rate of heating is absolutely essential for reproducibility of results.

(*b*) A thin, amalgamated copper plate or a sheet of filter paper placed on the bottom of the glass vessel will prevent the material from sticking to the bottom of the glass vessel, thereby saving considerable time and trouble in cleaning.

Reproducibility

7. With care and proper attention to details, duplicate determinations of softening point by this method should not differ by more than 1.0 C. (1.8 F.).

TENTATIVE REVISIONS
OF
A.S.T.M. STANDARDS

Tentative revisions of A.S.T.M. Standards are printed for one or more years with a view of eliciting criticisms, of which the committee concerned will take due cognizance before recommending final action.

Members of the Society and others are invited to direct written criticisms of any of these Tentative Revisions to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

TENTATIVE REVISIONS OF A.S.T.M. STANDARDS

Tentative Revision[1] of Standard Specifications for Alloy-Steel Bolting Material for High-Temperature Service (A.S.T.M. Designation: A 96 – 33):[2]

Explanatory Note.—Change the Explanatory Note, appearing at the end of these specifications, to read as follows:

NOTE.—Allowable pressures and their corresponding allowable temperatures are given in the following table. Higher temperatures with appropriate pressures may be used at the discretion of the designing engineer.

TABLE I.—MAXIMUM SERVICE PRESSURES FOR POWER PIPING AND OIL PIPING AT TEMPERATURES BELOW AND ABOVE 750 F.

Primary Service Pressure Rating at 750 F., lb. per sq. in.	100	300	400	600	900	1500
SERVICE TEMPERATURE, DEG. FAHR.	MAXIMUM SERVICE PRESSURES, LB. PER SQ. IN.					
POWER PIPING AND OIL PIPING						
100	230	500	670	1000	1500	2500
150	220	480	640	960	1440	2400
200	210	465	620	930	1395	2325
250	200	450	600	900	1350	2250
300	190	435	580	870	1305	2175
350	180	420	560	840	1260	2100
400	170	405	540	810	1215	2025
450	160	390	520	780	1170	1950
500	150	375	500	750	1125	1875
550	140	360	480	720	1080	1800
600	130	345	460	690	1035	1725
650	120	330	440	660	990	1650
700	110	315	420	630	945	1575
750	100	300	400	600	900	1500
POWER PIPING						
800	85	250	335	500	750	1250
850	70	200	270	400	600	1000
OIL PIPING						
800	92	275	370	550	830	1380
850	82	245	330	490	740	1230
900	70	210	280	420	630	1050
950	55	165	220	330	495	825
1000	40	120	160	240	360	600

Reference may be made to the dimensional standards for hydraulic pressure ratings and corresponding temperatures formulated by the Sectional Committee on Standardization of Pipe Flanges and Fittings, under the procedure of the

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[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[2] 1936 Book of A.S.T.M. Standards, Part I.

American Standards Association, A.S.A. Project B 16 and more specifically to the American Standard for Steel Flanged Fittings and Companion Flanges, B 16e – 1932. Copies of this American Standard are obtainable from the American Standards Association or from the American Society of Mechanical Engineers, 29 West 39th St., New York City.

Revision submitted, June, 1934; Modified, August, 1934.

Section 16.—Change this section to read as follows by the addition of the italicized words, the chemical requirements remaining the same:

16. Bolts and studs shall be equipped with semifinished nuts of American Standard heavy dimensions, chamfered and trimmed. *Nuts shall be made by the cold-punched or hot-forged, cold-trimmed process; nuts cut from drawn or rolled bar stock shall not be permitted.* If washers are used under nuts, they shall be of forged or rolled steel. All nuts and washers shall be free from injurious defects and shall have a workmanlike finish. Nuts shall conform to the chemical requirements for phosphorus and sulfur as follows.

Revision submitted, June, 1934.

Section 17.—Change this section to read as follows by the addition of the italicized words:

17. American National Standard coarse screw threads shall be used, except that no stud *or bolt* shall have less than eight threads per inch.

Revision submitted, June, 1934.

Tentative Revision[1] of Standard Specifications for Slab Zinc (Spelter) (A.S.T.M. Designation: B 6 – 33):[2]

Section 1.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

1. These specifications cover [Virgin Spelter, that is,] slab zinc (spelter) made from ore or [similar raw] *other* material by a process of [reduction and] distillation or by electrolysis, and not produced [from reworked metal] *by "sweating" or remelting of secondary zinc,* in six grades, as follows:

(1a) Special High Grade
(1) High Grade
(2) Intermediate
(3) Brass Special
(4) Selected
(5) Prime Western

Revision submitted, June, 1935.

Section 2.—Change to read as follows by the omission of the words in brackets:

2. A brand shall be cast in each slab by which the maker [and grade] can be identified.

Revision submitted, June, 1935.

Section 4.—In the table of requirements as to chemical composition change the lead content for Special High Grade Zinc (Grade *1a*) from

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[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[2] 1936 Book of A.S.T.M. Standards, Part I.

"0.010 per cent" to read "0.007 per cent"; also change the iron content for High Grade Zinc (Grade *1*) from "0.03 per cent" to read "0.02 per cent."

Revision submitted, June, 1935.

Section 8.—Change to read as follows by the addition of the italicized words:

8. Where the slab zinc (spelter) satisfies the chemical and physical requirements of these specifications, it shall not be condemned *for defects in manufacturing,* for defects of alloys in which it is used, or for defects in the coating of galvanized products.

Revision submitted, June, 1935.

Tentative Revision[1] of Standard Specifications for Manganese-Bronze Ingots for Sand Castings (A.S.T.M. Designation: B 7 – 27):[2]

Section 3.—Change the table of chemical requirements appearing in this section to read as follows by the addition of the italicized words and figures and the omission of the figures in brackets:

	Maximum	Minimum
Copper, per cent	[60] *62.0*	55.0
Zinc, per cent	[42] *remainder*	[38] *remainder*
Tin, per cent	1.5	0.0
Manganese, per cent	3.5	[0.0] *0.2*
Aluminum, per cent	1.5	[0.0] *0.5*
Iron, per cent	2.0	[0.0] *0.6*
Lead, per cent	[0.2] *0.4*[a]	0.0

[a] In the case of the Specifications for Castings (B 54) the present requirement for lead is 0.4 per cent; the proposed change is intended to apply only to the lead content requirement in the Specifications for Ingots (B 7).

Revision submitted, June, 1936.

Tentative Revision[1] of Standard Specifications for Manganese-Bronze Sand Castings (A.S.T.M. Designation: B 54 – 27):[2]

Section 3.—Make the same change in this section as recommended in Section 3 of Specifications B 7 – 27, above.

Revision submitted, June, 1936.

Tentative Revision[1] of Standard Specifications for Quicklime for Structural Purposes (A.S.T.M. Designation: C 5 – 26):[2]

The Tentative Specifications for Quicklime for Structural Purposes (C 5 – 34 T)[3] are in effect a tentative revision of and are intended to replace when adopted the present Standard C 5 – 26.

Tentative Revision[1] of Standard Specifications for Hydrated Lime for Structural Purposes (A.S.T.M. Designation: C 6 – 31):[2]

The Tentative Specifications for Hydrated Lime for Structural Purposes (C 6 – 34 T)[3] are in effect a tentative revision of and are intended to replace when adopted the present Standard C 6 – 31.

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[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[2] 1936 Book of A.S.T.M. Standards, Part II.

[3] *Proceedings,* Am. Soc. Testing Mats., Vol. 34, Part I, pp. 749, 752 (1935); also 1936 Book of A.S.T.M. Tentative Standards, pp. 410, 413.

Tentative Revision[1] of Standard Specifications for Concrete Sewer Pipe (A.S.T.M. Designation: C 14 - 35):[2]

Section 1.—Add the following footnote:

Caution.—The consumer or purchaser is cautioned against using cement-concrete pipe where the sewage shows an acid reaction.

Revision submitted, June, 1924.

Tentative Revision[1] of Standard Specifications for Building Brick (Made from Clay or Shale) (A.S.T.M. Designation: C 62 - 30):[2]

The Tentative Specifications for Building Brick (Made from Clay or Shale) (C 62 - 36 T)[3] are in effect a tentative revision of and are intended to replace when adopted the present Standard Specifications C 62 - 30.

Tentative Revision[1] of Standard Methods of Testing Brick (Compression, Flexure, Absorption) (A.S.T.M. Designation: C 67 - 31):[2]

The Tentative Methods of Testing Brick (Modulus of Rupture, Compressive Strength, Absorption) (C 67 - 36 T)[4] are in effect a tentative revision of and are intended to replace when adopted the present Standard Methods C 67 - 31.

Tentative Revision[1] of Standard Method of Test for Determination of Voids in Fine Aggregate for Concrete (A.S.T.M. Designation: C 30 - 22):[2]

The Tentative Method of Test for Determination of Voids in Coarse Aggregate for Concrete (Dry Rodded) (C 30 - 35 T)[5] is intended to be included, when adopted, with the present Standard Method C 30 - 22.

Tentative Revision[1] of Standard Definitions for Fireclay Refractories (A.S.T.M. Designation: C 27 - 35):[2]

Add the following new definition:

Super Duty Fireclay Brick.—A fireclay brick having a P. C. E. not lower than Cone No. 33 on the fired product, determined in accordance with the Standard Method of Test for Pyrometric Cone Equivalent of Fire Clay and Fire Brick (A.S.T.M. Designation: C 24); a shrinkage of not more than 1 per cent, determined in accordance with Section C of the Standard Method of Test for Permanent Linear Change After Reheating of Refractory Brick (A.S.T.M. Designation: C 113); and an average loss in spalling test of not more than 4 per cent, determined in accordance with the Tentative Method of Panel Test for Resistance to Thermal and Structural Spalling of Super Duty Fireclay Brick (A.S.T.M. Designation: C 122 - 36 T) of the American Society for Testing Materials.

Revision submitted, June, 1935; Modified, June, 1936.

Tentative Revision[1] of Standard Definitions of Terms Relating to Refractories (A.S.T.M. Designation: C 71 - 36):[2]

Several definitions of terms published under the title "Tentative Definitions of Terms Relating to Refractories (C 71 - 36 T)"[6] are intended to be added when adopted to the present Standard Definitions C 71 – 36.

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[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[2] 1936 Book of A.S.T.M. Standards, Part II.

[3] See p. 773.

[4] See p. 780.

[5] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 846 (1935); also 1936 Book of A.S.T.M. Tentative Standards, p. 517.

Tentative Revision[1] of Standard Definitions of Terms Relating to the Gypsum Industry (A.S.T.M. Designation: C 11 – 28):[2]

Several definitions of terms published under the title "Tentative Definitions of Terms Relating to the Gypsum Industry (C 11 – 31 T)"[3] are intended to be added when adopted to the present Standard Definitions C 11 – 28.

Tentative Revision[1] of Standard Definition of the Term Sand (A.S.T.M. Designation: C 58 – 28):[2]

The Tentative Definition of the Term Aggregate (C 58 – 28 T)[4] is intended to be included, when adopted, with the present Standard Definition C 58 – 28.

Tentative Revision[1] of Standard Specifications for Lithopone (A.S.T.M. Designation: D 208 – 26):[2]

Section 3 (b).—Change the requirement for zinc oxide from its present value of "2.0 per cent max." to read "1.0 per cent max."

Revision submitted, June, 1936.

Tentative Revision[1] of Standard Specifications for Raw Tung Oil (A.S.T.M. Designation: D 12 – 33):[2]

Section 1.—In the table of properties and tests change the requirement for specific gravity from its present form: namely,

	MAXIMUM	MINIMUM
Specific Gravity at 15.5°/15.5° C....................	0.943	0.9400

to read as follows:

Specific Gravity at 15.5/15.5 C......................	0.943	0.940[a]

[a] For American grown tung oil the minimum specific gravity may be as low as 0.938.

Revision submitted, June, 1935.

Section 3.—Change the descriptions of the heating test and the quality test described in Paragraphs (*h*) and (*i*), respectively, from their present form to read as follows:

(*h*) *Heating Test.*—The test tubes for the oil shall be 15 cm. by 16 mm., with a mark near the bottom to indicate 5 ml. Each tube shall be closed by a cork so perforated that a glass rod 3 mm. in diameter may be moved freely. The tubes shall each weigh 14.5 ± 2.0 g. (The purpose of this requirement is to control the wall thickness.)

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[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[2] 1936 Book of A.S.T.M. Standards, Part II.

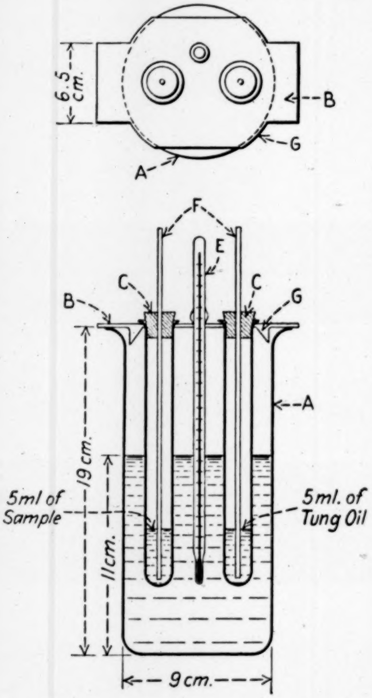
[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 749 (1935); also 1936 Book of A.S.T.M. Tentative Standards, p. 424.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 835 (1928); also 1936 Book of A.S.T.M. Tentative Standards, p. 518.

Fill a 1000-ml. tall-form glass beaker (height 19 cm., diameter about 9 cm.) with cottonseed oil or other suitable oil to a height of 11 cm. Place the thermometer as shown in Fig. 1 so that the bottom will be level with the bottoms of the test tubes.

Use a nitrogen-filled, chemical thermometer, engraved stem, total length 4 to 4½ in., graduated from 210 to 310 C. in 2 C. intervals; the length between 210 and 310 C. not less than 2½ in. Thermometer glass shall be well annealed. This thermometer may be suspended in the bath by a wire or may be sealed to a glass rod as shown in Fig. 1.

When the bath temperature is 293 C. (560 F.) and very slowly rising at this point, place the tube containing 5 ml. of the oil to be tested and the tube containing 5 ml. of a control sample of known value into the large holes of the cover. Note the time. Remove the source of heat for about 45 sec. and then re-apply. Before 2 min. have elapsed the temperature of the bath will have fallen to 282.2 C. (540 F.), at which point it should be kept as steady as possible. When the samples have been in the bath 9 min. raise the glass rods at intervals of 15 sec. Note the time when each sample becomes firmly set. At this period the oil will be so stiff that the entire tube may be lifted by aid of the rod. As setting or jellying takes place within a few seconds of fluidity, a good end point is afforded. Remove the samples. Heat the bath again to 293 C. (560 F.), and repeat the experiment with fresh portions of the sample.



A. 1000-ml. tall-form beaker, 9 cm. in diameter by 19 cm. in height.
B. Support plate about 6.5 cm. wide, made of Monel metal, aluminum or stainless steel.
C. Corks.
D. Test tubes 15 cm. by 16 mm.
E. Thermometer, range 210 to 310 C.
F. Glass rods 3 mm. in diameter.
G. Guide to prevent cover from slipping.

FIG. 1.—Tung Oil Heating Test Apparatus (Revised, 1935).

No stirrer is used in the bath. A screen around the bath enables the temperature to be reached more easily. When the bath oil has become tarry and viscid, it should be renewed; otherwise heating may be irregular.

(*i*) *Quality Test.*[1]—The apparatus required for this test consists of an ordinary vitreous enameled iron casserole having a bottom diameter of 7.5 cm. (3 in.); a wide flange tripod with a 7.5-cm. (3-in.) opening (the object of the flange is to prevent super-heating of the sides of the casserole); a total-immersion chemical thermometer, range 30 to 300 C. and 14 to 15 in. in length.

Put into the casserole 150 g. of the oil and heat so that the temperature reaches 282.2 C. (540 F.) in 4 min. ±30 sec., stirring with the thermometer. Turn down the flame and hold the heat as near 282.2 C. ±1 C. (540 F. ± 2 F.) as possible, stirring with the thermometer, until on lifting the latter, the oil drops with a pronounced string, showing that polymerization has started. The time required after reaching 282.2 C. (540 F. ± 2 F.) until the string is noted, is the time of the heat test. For pure tung oils this will not exceed 8 min. As soon as the oil strings, remove the lamp and the thermometer, and stir with a stiff spatula until the oil is solid. After stringing, a pure tung oil will require not over 40 sec. more to become solid. When solid, allow to stand just 1 min., then turn out, upside down, on clean paper and cut at once with a clean spatula.

Pure tung oil gives a gel that is dry, not adhering to the spatula when cut, that is firm, crumbling under pressure of the spatula without sticking, and the cut portions should crumble under pressure like dry bread crumbs. Adulterated tung oil gives a gel that is soft, sticky, and which will not crumble.

Revision submitted, June, 1935.

Tentative Revision[2] of Standard Methods of Sampling and Testing Shellac (A.S.T.M. Designation: D 29 - 33):[3]

Section 19.—Delete this section which describes the procedure for the determination of wax in orange, button, seed, and regular bleached shellac.

Revision submitted, June, 1936.

Tentative Revision[2] of Standard Methods of Testing Oleo-Resinous Varnishes (A.S.T.M. Designation: D 154 - 28):[3]

The Tentative Methods of Testing Oleo-Resinous Varnishes (Skinning Test, Alkali Resistance, Acid Number (D 154 - 35 T)[4] are in effect a tentative revision of and are intended to replace when adopted the present Standard Methods D 154 - 28.

Tentative Revision[2] of Standard Methods of Routine Analysis of White Linseed Oil Paints (A.S.T.M. Designation: D 215 - 35):[3]

Nature of the Thinner.—Add the following paragraph at the end of this section:

When the amount of turpentine in the thinner is small so that its presence is questionable, it may be detected by placing two drops of the distillate and 2 to 3 ml. of chloroform in a dry test tube and adding one drop of antimony pentachloride. A slow or slight change in color will indicate the absence of turpentine. A rapid change in color to a dark red or purple will indicate the possibility of turpentine. The iodine number for turpentine by the Wijs method under these conditions is approximately 340. An iodine number of 20 or over will give additional proof of the presence of turpentine and enable calculation of the approximate amount.

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[1] Based on Worstall test.

[2] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[3] 1936 Book of A.S.T.M. Standards, Part II.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part I, p. 887 (1935); also 1936 Book of A.S.T.M. Tentative Standards, p. 588.

Revision submitted, June, 1935.

Tentative Revision[1] of Standard Specifications for Broken Slag for Waterbound Base and Wearing Course (A.S.T.M. Designation: D 65 - 23):[2]

Section 4.—Omit this section, reading as follows, renumbering the subsequent sections accordingly:

4. The percentage of wear shall be not more than 12.0 per cent.

Revision submitted, June, 1924.

Section 6.—Change the last line of this section to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

[Retained on] *Passing* 2½-in. screen . . . not [less] *more* than [85] *15* per cent.

Revision submitted, June, 1924.

Section 7 (b).—Omit this paragraph which refers to the method for determining the percentage of wear.

Revision submitted, June, 1924.

Tentative Revision[1] of Standard Specifications for Shovel-Run or Crusher-Run Broken Slag for Waterbound Base (A.S.T.M. Designation: D 66 - 23):[2]

Section 4.—Omit this section, reading as follows, renumbering the subsequent sections accordingly:

4. The percentage of wear shall be not more than 15.0 per cent.

Revision submitted, June, 1924.

Section 6 (b).—Omit this paragraph which refers to the method for determining the percentage of wear.

Revision submitted, June, 1924

Tentative Revision[1] of Standard Specifications for Block for Granite Block Pavements (A.S.T.M. Designation: D 59 - 26):[2]

Section 3 (a).—Change to read as follows by the addition of the italicized words:

3. (*a*) The percentage of wear and the French coefficient of wear shall be determined in accordance with the Standard Method of Test for Abrasion of Rock (A.S.T.M. Designation: D 2) of the American Society for Testing Materials, ***except that the sample shall be prepared by use of a press and the fragments shall be as uniform and as nearly cubical as practicable.***

Revision submitted, June, 1929.

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[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[2] 1936 Book of A.S.T.M. Standards, Part II.

Tentative Revision[1] of Standard Specifications for Block for Recut Granite Block Pavements (A.S.T.M. Designation: D 131 – 23):[2]

Section 3 (*a*).—Make the same change in this section as recommended in Section 3 (*a*) of Specifications D 59 – 26 above.

Revision submitted, June, 1929.

Tentative Revision[1] of Standard Specifications for Block for Durax Granite Pavements (A.S.T.M. Designation: D 132 – 23):[2]

Section 3 (*a*).—Make the same change in this section as recommended in Section 3 (*a*) of Specifications D 59 – 26 above.

Revision submitted, June, 1929.

Tentative Revision[1] of Standard Specifications for Chafer Tire Fabrics (A.S.T.M. Designation: D 316 – 34):[2]

Section 1.—Change this section to read as follows by the addition of the italicized words and figures:

1. These specifications cover commercial 8, 9, 12 and 14-oz. ***plied yarn and 8.25, 11.65 and 14-oz. single yarn*** chafer tire fabrics made of carded American cotton of the following constructions:

Add the following to the present tabulation of constructions which follows Section 1:

8.25 oz.........single yarn warp and filling.........clean white cotton, no waste
11.65 oz.........single yarn warp and filling.........clean white cotton, no waste
14.00 oz.........single yarn warp and filling.........clean white cotton, no waste

Revision submitted, August, 1934.

Table I.—Add to Table I the following requirements covering 8.25, 11.65 and 14-oz. single yarn chafer tire fabrics:

		8.25-oz. Single Yarn			11.65-oz. Single Yarn			14.00-oz. Single Yarn		
		Std.	Min.	Max.	Std.	Min.	Max.	Std.	Min.	Max.
Width, in		60	59.5	60.5	60	59.5	60.5	60	59.5	60.5
Weight, oz. per sq. yd		8.25	8.0	8.5	11.65	11.35	11.95	14.0	13.60	14.4
Count	Warp	32.0	31.3	32.7	32.0	31.3	32.7	23.0	22.5	23.5
	Filling	28.0	26.9	29.1	28.0	26.9	29.1	23.0	22.1	23.9
Thickness (Gage), in		0.0290	0.0273	0.0307	0.0310	0.0295	0.0325	0.0390	0.0370	0.0410
Tensile Strength,[a] lb. Grab Test, Conditioned[b]	Warp	....	95	....	....	145	....	....	160	....
	Filling	....	95	....	....	155	....	....	170	....
Crimp, per cent	Warp	16.0	14.4	17.6	16.0	14.4	17.6	16.0	14.4	17.6
	Filling	9.0	7.2	10.8	9.0	7.2	10.8	9.0	7.2	10.8

[a] Tensile strength values are based on tests made on a 400 to 800-lb. capacity horizontal testing machine of inclination balance type.

[b] Preferred Method, in standard condition or corrected to standard moisture regain (6.5 per cent).

Revision submitted, August, 1934.

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[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[2] 1936 Book of A.S.T.M. Standards, Part II.

Tentative Revision[1] of Standard Specifications for Tolerances and Test Methods for Tire Cord, Woven and on Cones (A.S.T.M. Designation: D 179 - 33):[2]

Section 26.—Change the last paragraph from its present form: namely,

> A record shall be made of deviations from the scale or chart readings and corresponding corrections shall be made on the machine.

to read as follows:

> When a machine is found to be in a satisfactory mechanical condition, meets the sensitivity requirements of Section 25 and then shows deviations between weights applied and dial readings, the following is considered a valid method of correction: Construct an empirical dial, the points on which shall be located by the position of the machine pointer after application of various weights as prescribed in this section.

Revision submitted, June, 1935.

Tentative Revision[1] of Standard Methods of Testing Molded Materials Used for Electrical Insulation (A.S.T.M. Designation: D 48 - 33):[2]

Section 3.—Change to read as follows by the addition of the italicized words:

> 3. For hot-molded materials and for plastic cold-molded materials (see Note 1), the test specimen shall be molded to the form and dimensions shown in Fig. 1 (*b*), ***either the ⅛-in. or the ¼-in. test specimen being permissible*** (*see Note 2*).

Add a note to this section to read as follows:

> NOTE 2.—Values for tensile strength obtained with these two specimens may be unequal and that specimen considered most representative of the material and its use should be chosen.

Revision submitted, August, 1936.

Figure 1.—In Fig. 1 (*a*) omit the thickness dimension ($\frac{1}{16}$ in.) of the spacing plate and substitute for it the letter *C*. In Fig. 1 (*b*) omit the thickness dimensions 0.250 in. (6.3 mm.) and 0.375 in. (9.5 mm.) and substitute letters *A* and *B*. Add to Fig. 1 the following table:

	A	B	C
For ⅛-in. specimen...	0.125 in. (3.2 mm.)	0.250 in. (6.3 mm.)	0.125 in. (3.2 mm.)
For ¼-in. specimen...	0.250 in. (6.3 mm.)	0.375 in. (9.5 mm.)	0.062 in. (1.6 mm.)

Revision submitted, August, 1936.

Section 10.—Change this section which describes the flexure test apparatus to read as follows by the addition of the italicized words and the omission of those in brackets:

> 10. Any standard testing machine may be used provided it is accurate to within 1 per cent for the lowest load for which it is used. The distance between

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[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[2] 1936 Book of A.S.T.M. Standards, Part II.

points of support shall be 4 in. (102 mm.). The supports shall have the contact edges rounded to a radius of ⅛ in. (3.18 mm.). The load shall be applied [parallel to and in the same direction that] ***perpendicular to the direction in which*** the molding pressure was applied, midway between the supports by a pressure piece, the bearing edge of which shall be rounded to a radius of ⅛ in. (3.18 mm.).

Revision submitted, August, 1934.

Section 11.—Change this section from its present form: namely,

11. The test specimen shall be molded to the dimensions shown in Fig. 3.

to read as follows:

11. The test specimen shall be molded to the dimensions shown in Fig. 3. The thickness of the molded specimen, that is, the dimension parallel to the application of the molding pressure may be any value of ½ in. or less agreed upon as representative of the cross section in which the material is to be used. The thickness as molded will be the width of the beam when under test.

NOTE.—When the specimen is less than ¼ in. in molded thickness difficulties may be encountered due to tipping over or unsteadiness during test. In such cases the test may be made upon a composite specimen consisting of sufficient individual pieces to aggregate approximately ½ in. in beam width held together by a rubber band or other light clamp.

Revision submitted, August, 1934.

Section 13.—Change this section to read as follows by the addition of the italicized words and the omission of those in brackets:

13. The report shall include the following:

(*a*) The thickness and width ***as molded*** of each specimen [as] measured by a micrometer in inches or millimeters;

(*b*) The load on each specimen in pounds or in kilograms at the first sign of failure;

(*c*) The maximum fiber stress in pounds per square inch or in kilograms per square millimeter calculated from the formula:

$$S = \frac{3Pl}{2bd^2}$$

in which S = maximum fiber stress, P = load applied, l = distance between [the supports] ***points of support***, b = width of [specimen] ***the beam as tested***, and d = depth of [specimen] ***the beam as tested;***

(*d*) The rate at which the load was applied;

(*e*) The maximum deflection at the center in inches or in millimeters.

Revision submitted, August, 1934.

Figure 3.—Change this figure which shows the flexure test specimen by omitting the ½-in. dimension under the side view and substituting the following note: "Thickness in accordance with Section 11." Add an arrow showing "direction of molding pressure" perpendicular to the remaining ½-in. dimension. Retain the note under the figure caption.

Revision submitted, August, 1934.

Resistance to Impact.—Add the following as a new Section 14, renumbering the remaining sections accordingly:

14. (*a*) Resistance to impact shall be determined in accordance with the Tentative Methods of Testing Electrical Insulating Materials for Resistance to Impact (A.S.T.M. Designation: D 256 – 34 T) of the American Society for Testing Materials.[1]

(*b*) *Test Specimens.*—Specimens for the Charpy test may be notched or unnotched as desired, according to conditions of service. The Izod test specimens shall be notched.

NOTE.—The unnotched specimen gives a higher strength than the notched specimen and the ratio of the strength of the unnotched specimen to that of the notched specimen varies with different materials.

Revision submitted, August, 1934; Modified, June, 1936.

Sections 14 to 17, inclusive.—Replace this material, describing dielectric strength tests at commercial power frequencies, by the following new Section 15, renumbering the present Sections 18 to 24, inclusive, accordingly:

DIELECTRIC STRENGTH

15. The dielectric strength shall be determined in accordance with the Tentative Methods of Testing Sheet, Tape, and Molded Insulating Materials for Dielectric Strength (A.S.T.M. Designation: D 149 – 36 T) of the American Society for Testing Materials.[2]

Revision submitted, June, 1934.

Tentative Revision[3] of Standard Methods of Testing Electrical Insulating Oils (A.S.T.M. Designation: D 117 – 36):[4]

New Section.—Add the following as new Section 10, renumbering the remaining sections accordingly:

10. *Color.*—The test to determine color shall be made in accordance with the Tentative Method of Test for Color of Lubricating Oils by Means of A.S.T.M. Union Colorimeter (A.S.T.M. Designation: D 155 – 34 T) of the American Society for Testing Materials.[1]

Revision submitted, June, 1935.

Tentative Revision[3] of Standard Methods of Laboratory Sampling and Analysis of Coal and Coke (A.S.T.M. Designation: D 271 – 33):[4]

Section 14 (*b*).—Change from its present form: namely,

(*b*) *Modification for Subbituminous Coal, Lignite, and Peat.*—Mechanical losses are incurred on suddenly heating peat, subbituminous coal, and lignite; therefore, they must be subjected to a preliminary gradual heating for 5 minutes; this is best done by playing the flame of a burner upon the bottom of the crucible in such a manner as to bring about the discharge of volatile matter at a rate not sufficient to cause sparking. After the preliminary heating, transfer the crucible to the volatile-matter furnace and heat for 6 minutes at 950 C. as in the regular method described in Paragraph (*a*).

NOTES: The cover should fit closely enough so that the carbon deposit from bituminous and lignite coals does not burn away from the under side.

Regulation of temperature to within the prescribed limits is important.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I, pp. 995, 885 (1934); also 1936 Book of A.S.T.M. Tentative Standards, pp. 905, 606.

[2] See p. 918.

[3] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[4] 1936 Book of A.S.T.M. Standards, Part II.

to read as follows:

(*b*) *Modification for Subbituminous Coal, Lignite, Peat, and Certain Cokes, Chars, Anthracites, and Semianthracites.*—Mechanical losses are incurred on suddenly heating peat, lignite, and subbituminous coal; such losses also occur with some low-temperature cokes, green cokes, chars, anthracites, and semianthracites. This mechanical loss is usually designated as "sparking" and is caused by particles of the fuel being ejected from the crucible by the too rapid escape of steam or volatile matter. These particles become incandescent in the flame of the burning volatile constituents and may be seen around the edge of the crucible cover, sometimes only ¼ in. above the crucible and at other times shooting several inches to the top of the furnace. In severe cases of sparking, ash deposits and sometimes unburned material will be found on the crucible cover. Small amounts of ash deposits are sometimes found on the crucible cover in case of moderately sparking fuels. All fuels which do not cake when volatile matter is determined shall be watched closely for sparking during the heating period; also, at the end of the test the crucible cover shall be inspected for ash deposits, and the presence of such deposits shall be considered as evidence of sparking.

(*c*) All fuels which spark appreciably when volatile matter is determined by the methods described in Paragraph (*a*) and Section 15, shall be given a preliminary gradual heating of not less than 5 min. nor more than 10 min. at increasing temperatures. This preliminary heating shall be done by the gradual lowering of the crucible into the furnace at such a rate that sparking does not occur. After this preliminary heating, the crucible shall be lowered into its regular position in the furnace and heated for exactly 6 min. at 950 C. as in the method described in Paragraph (*a*). If sparking is then observed the determination shall be rejected, and the test shall be repeated until no sparking occurs either during the preliminary heating or during the 6-min. period at 950 C.

(*d*) If the Meker burner method described in Section 15 is used for the volatile matter determination, the preliminary heating shall be done by playing the flame of a burner upon the bottom of the crucible in such a manner as to bring about the discharge of volatile matter at a rate not sufficient to cause sparking. After this preliminary heating, the crucible shall be heated for exactly 6 min. at 950 C. as described in Section 15. If sparking occurs during this 6-min. heating period the determination shall be rejected and another made.

NOTES: The cover should fit closely enough so that the carbon deposit from bituminous, subbituminous and lignitic coals does not burn away from the under side.

Regulation of temperature to within the prescribed limits is important.

With some strongly caking low-volatile and medium-volatile bituminous coals the coke button may be broken with explosive violence, due to the liberation of volatile matter within the button. This is usually designated as "popping." Such popping may blow the lid off the crucible and cause mechanical losses of the coked material. When such popping is observed, the determination shall be rejected and the test repeated until popping does not occur.

Revision submitted, June, 1936.

Tentative Revision[1] of Standard Definitions of Terms Relating to Coal and Coke (A.S.T.M. Designation: D 121 - 30):[2]

The Tentative Definition of the Term Coke (D 121 - 30 T)[3] is intended to be added when adopted to the present Standard Definitions D 121 - 30.

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[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[2] 1936 Book of A.S.T.M. Standards, Part II.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1147 (1930); also 1936 Book of A.S.T.M. Tentative Standards, p. 545.

Tentative Revision[1] of Standard Definitions of Terms Relating to Timber Preservatives (A.S.T.M. Designation: D 324 – 33):[2]

The following definition of the term "water-gas tar" is intended when adopted to be added to the Standard Definitions D 324 – 33:

Water-Gas Tar.—Tar produced in the manufacture of carbureted water gas by the decomposition of petroleum oil by heat in the presence of blue gas.

Revision submitted, June, 1933.

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[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society 260 S. Broad St., Philadelphia, Pa.

[2] 1936 Book of A.S.T.M. Standards, Part II.

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